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the small systems journal

The C Language

How to quickly re

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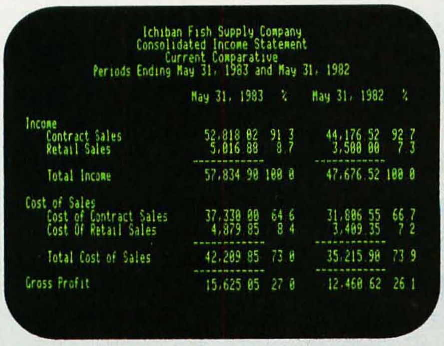
gain your balance.

on your customers and vendors.

So you know who owes whom, how much, and how come.

And just how well your cash flow is flowing.

And where to give credit where credit is due (a customer inquiry



Your Apple can generate instant income statements (with expense ratios) or balance sheets, and let you compare them to last month's or year's, then print them out to suit your banker.

feature allows you to make credit decisions based on the most current information).

You can also list your purchases by discount dates. And take advantage of them in no uncertain net terms. You can even keep payroll records without paying more, because it's part of the same package.

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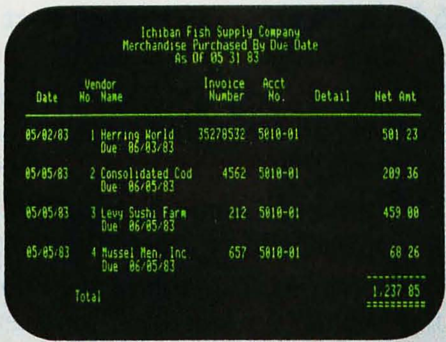

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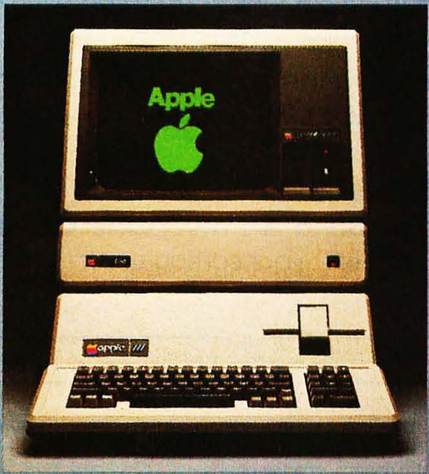

results will make an important statement to everyone you deal with—including your banker.

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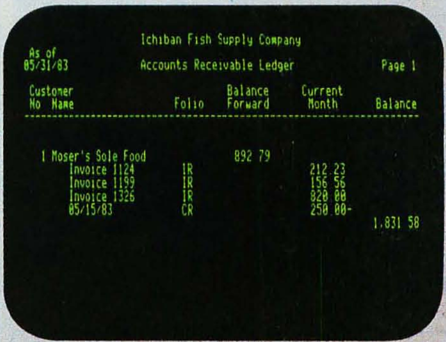
There are more people in more places doing more things with



To avoid fishy transactions, you can instantly display customer's payments, charges and current balance. In this case, a few more cans of tuna would put Mr. Moser over his $2,000 limit.

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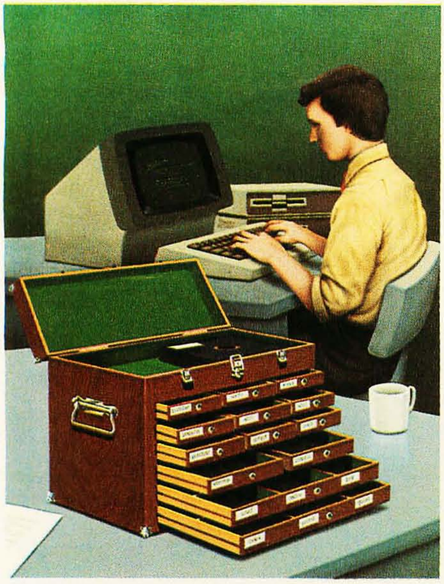
In The Queue

BYTE Volume 8, Number 8



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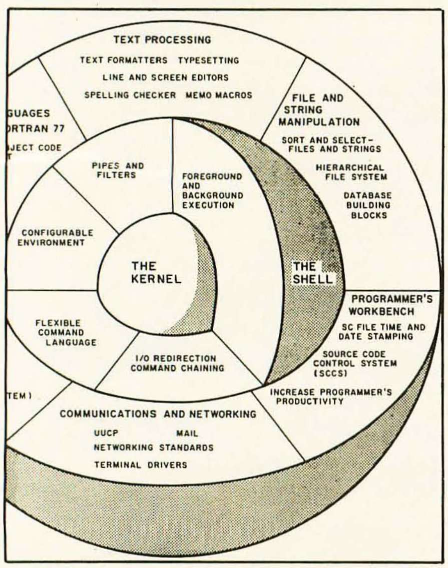

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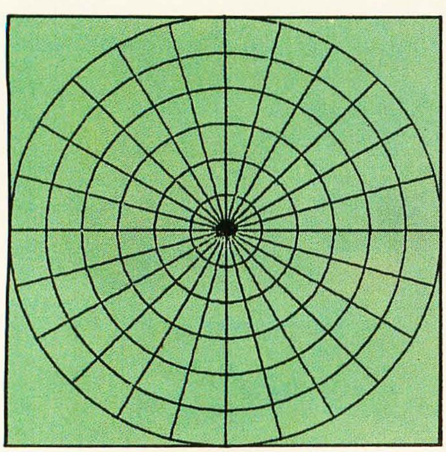

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Themes

Features

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Nucleus

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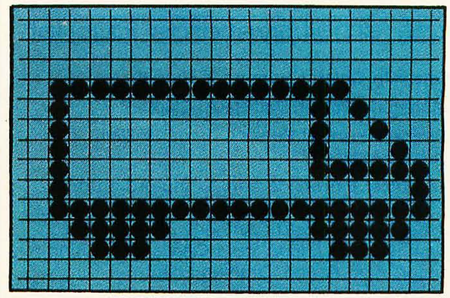

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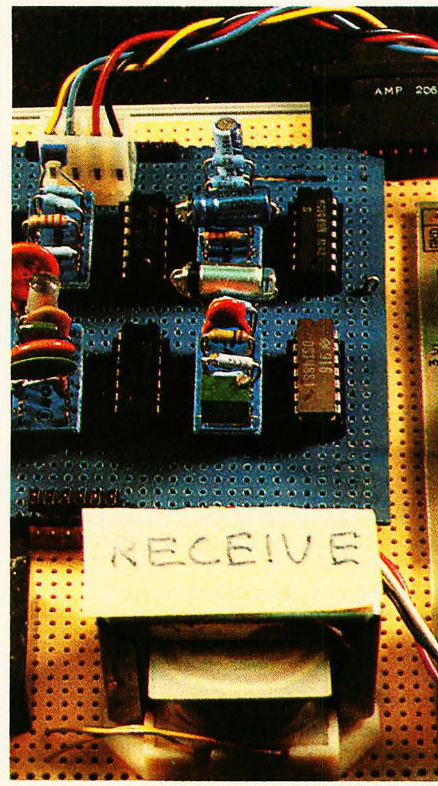

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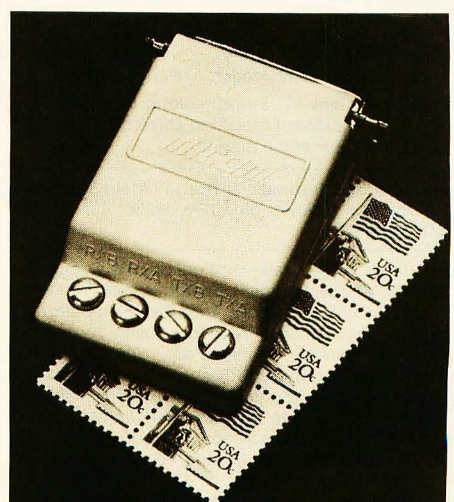

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Editorial

DEC, IBM, and Athena

Lawrence J. Curran, Editor in Chief

Forward-looking computer manufacturers are wise enough to understand that aiding education today can help computer sales tomorrow. IBM and Digital Equipment Corp. are two such companies. In an effort called Project Athena—after the Greek goddess of wisdom—DEC and IBM personal computers could become the tools of wisdom in the hands of undergraduate students at the Massachusetts Institute of Technology.

Both DEC and IBM will contribute goods and services valued at $50 million over the five-year span of the project, which is aimed at exploring how advanced computers and computer graphics can change the ways in which college students learn. The idea is to create a "coherent" network of computers that will enable students and faculty to share resources—hardware, software and ideas—so that together they can solve problems in creative ways.

MIT officials should be applauded for using the project to seek ways to make dissimilar computers work with the same languages and operating systems. At the same time, the two companies deserve recognition for agreeing to contribute computers and talent. It's conceivable that the project will take steps toward standardizing languages and operating systems, and anything that fosters standardization in the computer business is to be encouraged.

DEC will donate more than 300 display terminals, 1600 personal computers, 63 minicomputers, and the full-time services of five employees to Project Athena. Similarly, IBM will contribute the services of five employees, 500 personal computers, 500 single-user work stations, software, maintenance, and research grants.

While DEC and IBM merit recognition for their philanthropy, the fact that today's students are tomorrow's computer buyers must have appealed to the marketing departments of both companies, which stand to reap brand-recognition and loyalty benefits from the experiment. Lest we be accused of complete cynicism, however, it should be pointed out that DEC founder and president Kenneth Olsen is an MIT alumnus who has demonstrated his company's commitment to the community. Project Athena is evidence of this, as is DEC's decision to locate a plant in Boston's heavily black Roxbury district.

DEC and IBM recognize that an investment in education is worthwhile for its own sake, and certainly won't hurt future sales. Another company with the same approach is Apple Computer Inc., which recently donated $21 million worth of personal computers to 9250 public and private schools in California. We applaud these companies and would like to hear about others.■

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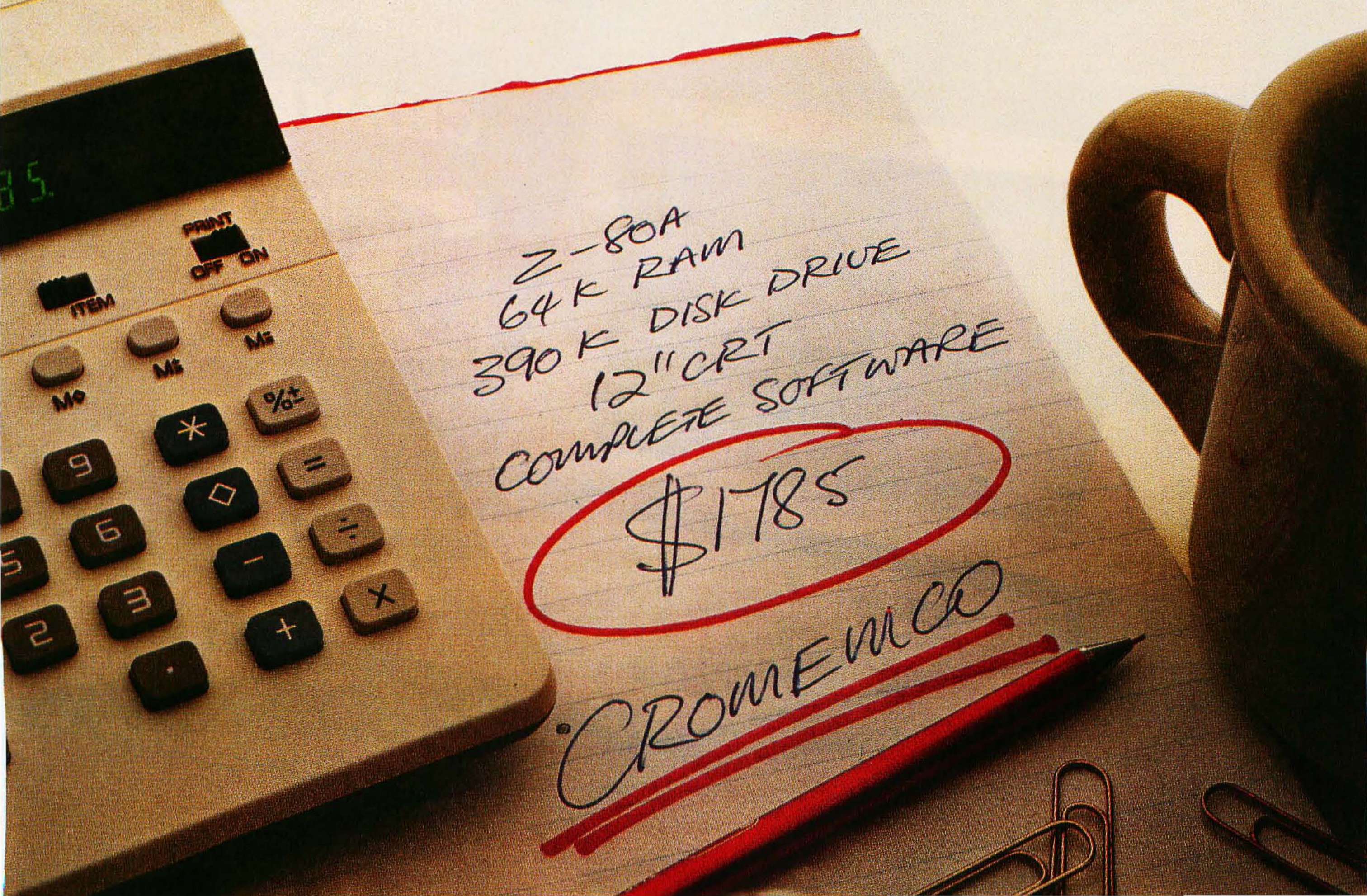

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MICROBYTES

Staff-written highlights of late developments in the microcomputer industry.

DIGITAL RESEARCH PLANS ALTERNATIVE TO MICROSOFT HARDWARE STANDARD

The proposed MSX standard announced by Microsoft, Spectravideo, and 14 Japanese computer manufacturers won't be the only attempt to define standard hardware and software parameters in the low-cost computer market. Digital Research is also backing a proposal to unify software standards and is talking with a number of Japanese manufacturers.

To meet the MSX standard, manufacturers must use a Zilog Z80 microprocessor, a Texas Instruments TMS9918A video processor, a General Instrument AY-8910 sound processor, a Nippon Electric Co. (NEC) cassette interface chip, an Atari joystick interface, 64K bytes of RAM, and Microsoft's 32K-byte ROM-based extended BASIC. Some of the components can be purchased from other suppliers.

NEC, one of the Japanese companies that Microsoft said supported the MSX format, plans to look at any and all attempts to standardize hardware and software for low-cost game computers and plans to remain neutral until all possibilities are considered.

Both Microsoft and Spectravideo expect the standard to have the greatest impact in Japan, where the lack of a standard has held the home computer market back.

In addition to NEC, the following companies were reported by Microsoft and Spectravideo to have supported the MSX standard: Matsushita (Panasonic), Sony, Sanyo, Hitachi, Canon, Mitsubishi, Toshiba, Fujitsu, Kyocera, General, Yamaha, Pioneer, and JVC.

Specifications for the bus, I/O addresses, and game cartridge were not complete at the time of the announcement but will be included in the standard. Disk-size and operating-system specifications will not be included, but any disk system or auxiliary processors can be added onto the bus.

This fall, Spectravideo, which began shipments of its two home computers in early June, will offer a $50 MSX adapter for its computers, one of which retails for $300. Microsoft, Spinnaker, Sierra On-Line, and Sirius have pledged software support for the MSX standard.

COLECO'S ADAM SHAKES UP THE LOW-COST COMPUTER MARKET

Coleco's Adam has stirred up the home computer market in more ways than one. The $600 machine was the talk of the summer Consumer Electronics Show because of its aggressively low price. Shortly afterward, however, Logical Business Machines sued Coleco and insisted that LBM owns the Adam name because it sells a much more expensive business computer called Adam. Coleco argues that it bought the trademark rights to the name from a firm that registered the name in 1976.

Coleco's Adam includes a 10-character-per-second letter-quality daisywheel printer, two Coleco Vision game controllers with numeric keypads, a ROM-based word processor, Applesoft-compatible Smart BASIC, and 80K bytes of RAM, all for less than $600. The Adam will also be available as an expansion unit for the Coleco Vision game system for less than $400. A "digital data pack" drive, which uses cassette-sized cartridges, is included, but Coleco would not discuss its specifications.

SOFTREND UNVEILS AURA, AN INTEGRATED SOFTWARE PACKAGE

Softrend, Wyndham, NH, announced that it will soon offer an integrated software package similar to Lotus's 1-2-3. Designed for the IBM PC and XT, Aura is built around a database manager whose various components are scheduled for release over the next few months.

Aura, the central database manager, will be released this month for $250. In November, Aura 3, which also includes a Multiplan-like spreadsheet program and a Wang-like word processor, will be available for $395. Aura 4, which has graphics capabilities, will also be introduced in November for $495. Aura 5, which is scheduled for a December release, will add IBM mainframe communications and will sell for $995. Aura will not use a mouse, but Softrend is considering voice input.

SMITH-CORONA UPDATES PRINTER, OFFERS COMPUTER-COMPATIBLE TYPEWRITER

Smith-Corona has released an updated version of its TP-1 daisywheel printer. The TP-2, a smaller and quieter printer, includes both serial and parallel ports and has DIP switches to select various print options. The TP-2 will list for $895. The list price of the TP-1, which has been offered by some dealers for less than $500, will drop from $895 to $695.

Smith-Corona also announced the Memory Correcting 3 Messenger, a computer-compatible daisywheel typewriter. It will include either a serial or parallel interface for $599. Like the TP-1 and TP-2, the typewriter prints 12 characters per second.

← Circle 353 on inquiry card.

IBM EMBRACES CONCURRENT CP/M-86 THROUGH DIRECT SALES

IBM's domestic sales force is now selling Digital Research's Concurrent CP/M-86 for the IBM PC and PC-XT. IBM's 9000 sales representatives will also offer Micropro's Wordstar, Ashton-Tate's dBase II, Chang Labs' Microplan financial planner, and Digital Marketing's Microlink communications program and Milestone project planner. The programs can run concurrently and can transfer data through text files. IBM's announcement, which may signal a shift in operating systems for the PC in office use, comes amid reports that IBM will emphasize direct sales of the PC at the expense of current retailers and distributors.

APPLE PRESENTS A NEW OPERATING SYSTEM FOR THE APPLE II

Apple Computer has announced ProDOS, a hierarchical, Unix-like operating system for the Apple II that is compatible with the Apple III's Sophisticated Operating System (SOS). ProDOS is now being supplied to qualified software developers and will be generally available in early 1984.

COMMODORE ANNOUNCES 70 SOFTWARE PACKAGES, INCLUDING MULTIPLAN AND MAGIC DESK

Commodore Business Machines has announced 70 new software packages for the Commodore 64, including a version of Microsoft's Multiplan spreadsheet for less than $100. Magic Desk, an integrated software package priced under $100, is intended to compete with Apple's Lisa and Visicorp's Visi On.

Magic Desk is actually a series of cartridges. The first, Type and File, will offer word processing and limited data management using pictures of a typewriter and file drawers and folders.

GAMELINE OFFERS ON-LINE VIDEO GAMES FOR THE ATARI VCS

Gameline, a new telecommunication system for owners of the Atari Video Computer System 2600 (VCS), is available from Control Video Corp., Vienna, VA. CVC will offer video games and information services to VCS owners who buy a Master Module cartridge, which includes an autodial modem and memory to store downloaded games or text.

Founded by William von Meister, who created The Source, Gameline will be priced at about $1 per game, after the initial $50 to $60 charge for the Master Module and a one-time $15 membership fee.

NANOBYTES

Jon Shirley, who was vice-president of computer merchandising for Tandy Corp. (Radio Shack), has left after 25 years at Tandy to become president of Microsoft Corp. . . . **Harris Semiconductor and Intel** jointly announced that both will produce a CMOS version of the Intel 8086 microprocessor and related support peripheral chips. Harris's 80C86 will be the first 16-bit CMOS microprocessor when it becomes available in the fall. Because CMOS chips require less power than regular NMOS microprocessors, the 80C86 will probably be used first in portable computers. National Semiconductor is working on a CMOS version of its 16-bit 16032 processor to be available in 1984. . . . **Microsoft** is developing Logo for Spectravideo computers. Priced at $49.95, Microsoft Logo for Spectravideo will be available by the fourth quarter of 1983 and for the MSX standard by early 1984. No additional peripherals are needed to run Logo on the $300 SV-318 or the SV-328. . . . **The Atari 1027,** a 20-character-per-second letter-quality printer for $349.95, will be available this fall. Bundled with the Atari 600XL computer and the Atariwriter word processor, the printer will sell for $599.95. . . . **Texas Instruments,** which cited the turbulent home computer market as the reason for a projected $100-million second-quarter loss, has cancelled its plans to produce the low-cost 99/2 computer announced in January. TI said it has shipped more than one million units of its 99/4A home computer and plans to introduce the 99/8, an "advanced home computer," in the fall. . . . **Microcom,** of Norwood, MA, has announced it will license the protocol used in its hardware and software communications products. Visicorp, Apple, and GTE Telenet have agreed to support the protocol as a standard, which simplifies file transfers between microcomputers. . . . **Softyme Inc.** of San Francisco, CA, will test its Softyme Express system in an El Cerrito, CA, Computerland store. The system includes a computer with a database of available programs. When a customer decides what software package to buy, the program is transmitted to the machine and copied onto single- or double-sided disks in IBM PC-DOS 1.1 or 2.0 format. . . . In November, **Radio Shack** will release a Videotex and Office Information System based on its Model 16B multiuser system. As many as 64 terminals at a time can access up to 256 databases on the system, priced at $12,000 and up. . . . **Digital Equipment Corp.** (DEC) announced a Winchester hard disk for its Professional Computer as well as changes to its operating system. DEC will soon begin selling its personal computers through its Business Centers.

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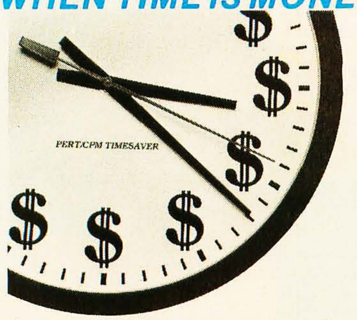

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Letters

Is Radiation Harmful?

Edward M. Gogol's letter (April, p. 14) presented some excellent thoughts about radiation. But I have one correction. He states, "Radiation levels decrease as the square of the distance from the screen." This is true for a point source of radiation. It is not true for a 12-inch screen.

To illustrate, consider a video screen the size of a movie theater screen. A person standing one foot from the screen then moving to a distance of two feet would receive almost identical radiation, not one-quarter the radiation, as the formula for point sources would indicate.

The radiation, I believe, would be proportional to the angular area subtended by the screen at one distance compared with the angular area of the second distance. This presumes equal radiation from all areas of the screen. As you can see, it starts to become complex.

Obe O. Doan
14710 Parthenia St.
Panorama City, CA 91402

Edward Gogol's letter does not belong in a magazine of BYTE's caliber.

1. Contrary to his claims, no variety of radiation can be eliminated completely.
2. A properly designed video display does not emit significant X-radiation when operated within its design limits.
3. The claim that "with radiation, there is no threshold" is a statement that nobody can make with certainty. There is evidence pointing in all directions, including evidence that more radiation extends life (Pearson and Shaw, *Life Extension*. Warner Books, 1982, p. 516).
4. The implication that microwave exposure below a level that causes significant heating in the body is harmful is a lie that would be funny if so many people did not believe it. Fear of microwaves is a much greater health hazard than microwaves.
5. On most terminals, turning down the brightness does not reduce the electron beam acceleration voltage but increases the voltage by a small amount due to the finite resistance of the high-voltage supply and the decrease of beam *current*. (Total high-energy radiation is likely to decrease, as Gogol claims.)
6. The claim that a light-emitting diode display emits no radiation is stupid. It radiates waste heat, it radiates very small amounts of "nuclear" radiation from impurities in the package, and it radiates light.
7. Gogol's references are highly suspicious. The Sierra Club is a well-known Luddite organization, and Gofman's public stance suggests that he is interested in advancing his prejudices rather than finding the truth. An earlier Gofman book was described by Peter Beckman as "grotesquely biased." *The Zapping of America* is a sensationalistic book of no more scientific merit than *The Chariots of the Gods*.

Christopher M. Maple
Chief Engineer
Ingrid's Computers
8377 Capistrano Ave.
Canoga Park, CA 91304

I read with interest the letter by Edward M. Gogol critical of Dr. John Villforth of the U.S. Bureau of Radiological Health on his assurances of the near-zero present risk from ionizing radiation from video displays. The irony of this attack is amazing: in the more than 10 years that I have known Villforth, he has conducted a one-man crusade against the hazards of dental x-ray machines in particular. In this he is supported by the National Health Physics Society, which consists of 5500 people nationwide engaged in protecting mankind from the effects of ionizing radiation.

The average natural radiation background in the United States is about 100 mR per year with a large deviation from the mean, which I will discuss later. However, the average black-and-white (includes single colors like green) display tubes, including TV tubes, have an accelerating potential of 12 to 16 kilovolts (kV). The 16-kV maximum x-rays produced by this type of tube are virtually unmeasurable at the faceplate because of its thickness of ⅜ to ½ inches of glass, which is necessary to protect the near-flat surface from the crushing pressure of the air outside. The full-color display, like its TV counterpart, requires an accelerating potential of about 25 kV and is capable of producing 25-kV maximum x-rays. Because the glass faceplate is of similiar thickness to that of the single-color tube, there is a greater risk for the escape of x-rays. Very sensitive devices are required

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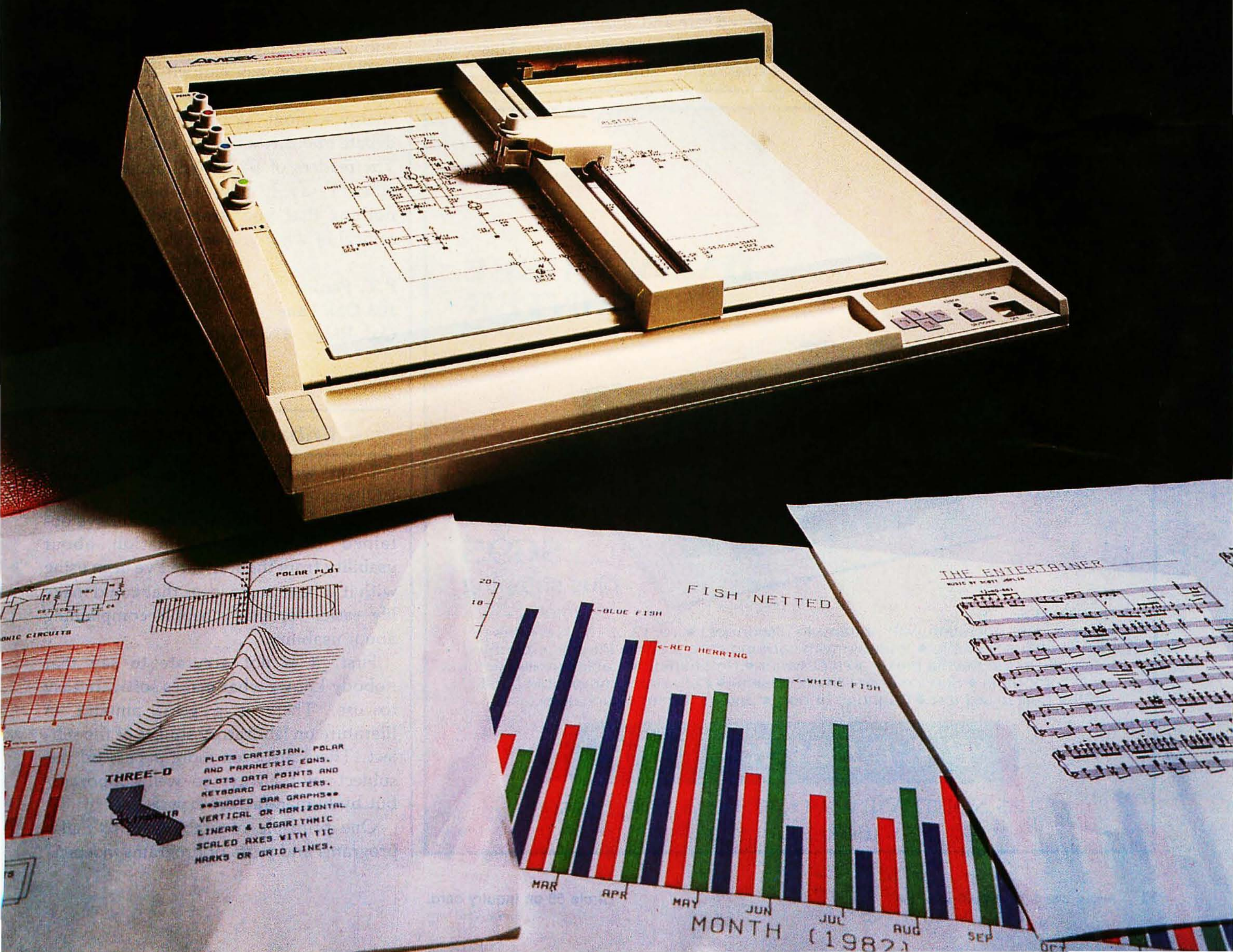


to measure these low-energy x-rays for the equivalent of 10 to 12 hours of use per day for a full year, at levels a small fraction of the 100 mR average annual dose. It is the function of the Bureau of Radiological Health to make such measurements and issue warnings if the background level is increased.

Surprisingly, the ionizing radiation potential of the video display and its counterpart, the TV screen, is not from its x-ray potential but from its efficiency as an electrostatic precipitator. In the air of all buildings there is a radioactive noble gas called radon. When radon decays, the radioactive daughters formed are positively charged and are attracted to the glass surfaces of the display tube, adhering to the glass until the daughter's decay. We have used this phenomenon for some years to estimate the amount of radon in homes. When the TV set is turned off and an alpha counter is applied to the screen, a rapid count indicates the need for especially careful radon daughter measurements. This buildup of radiation on the viewing screen may disturb Gogol, but I for one would rather have these radon daughters on the screen than in my lungs.

While the national average background is about 100 mR/year, there are wide variations. The area south of Chicago has water wells and radium-bearing soil that can increase this average by as much as 10 times. Similarly, the New England states have areas of granite rock in the ground that can increase the natural background 10 to 50 times. However, epidemiological studies indicate these states to be as healthy as any in the U.S. When actual measurements are substituted for assumptions, no correlation between radiation and health can be shown (Beck and Krey in *Science*, April 1983, pp. 18–24).

Gogol has quoted Dr. John Gofman's book *Radiation and Human Health* as the authority on ionizing radiation. Gofman and about 10 others have taken the position that the radiation dose below 10 mR/year is more harmful than the linear model will predict. However, most authorities have agreed that health effects cannot be scientifically verified below 10 mR/year. The linear model was *chosen* by the NCRP and the BEIR committees not because it could be scientifically verified but because the levels produced were considered safe and allowed dose calculations to be made relatively easier. This model extrapolates radiation effects from the 10 mR area to 0, where no radiation effects are assumed to be produced. In this no-man's-land below 10 mR, Dr. L. D. Luckey has also written a book called *Hormesis with Ionizing Radiation*, published by Chemical Rubber Press (the book costs $60, so it might be advisable to check it out of a library). Hormesis is a neologism that, loosely translated from the Greek, means "beneficial effects." Dr. Luckey has listed more than a thousand experiments with plants and animals that exhibit beneficial effects in the 10 to 50 mR/year region. He would be the first to point out that there is still no absolute proof. However, the total biological evidence is not helping the case of increased health effects/mR in the region below 10 mR/year, the position taken by Dr. Gofman and several others.

The second authority Gogol quotes is Paul Brodeur's *The Zapping of America*. The only review I have seen of this book is a short one in the *Health Physics Newsletter* warning that the book is long on claims and short on proof. Because the subject is radio frequency and microwaves, most readers of BYTE have enough background to deal with it.

This nation has enough troubles with the economy and displaced or discarded energy without taking sides in a scientific debate about whether or not harm exists. The readers of BYTE will agree with me when I say it pays to believe almost nothing that you hear and to be very critical of what you see.

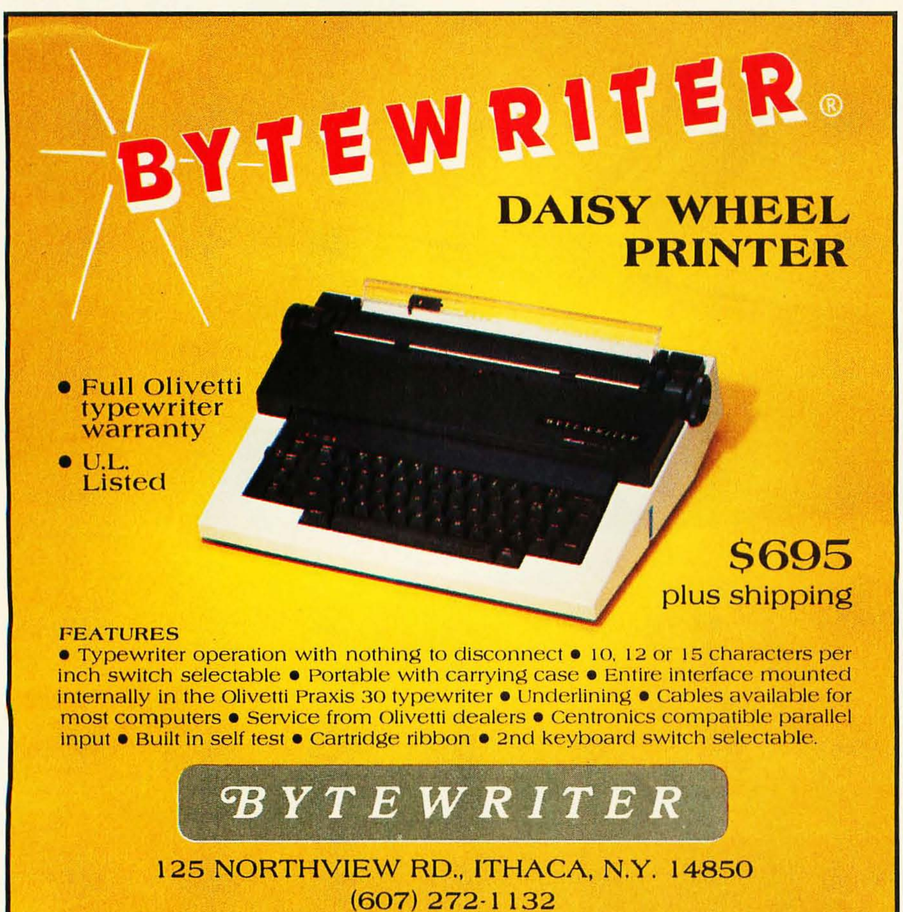
P.T. Perdue
103 Oak Lane
Oak Ridge, TN 37830

Enhancing Usability

I am writing in response to Gregg Williams' editorial (April, p. 6). Recently I purchased a microcomputer and have obtained first-hand information about usability from the software I've been using with it. I have some ideas that could make life easier for many people complaining about usability.

First, it is not accurate to say that nobody knows what makes software easy to use. There is a great amount of literature on laboratory studies of the subject. There are even more papers on the subject—not always so well supported, but by human-factors experts.

One principle of usability is to make programs and parts of programs indepen-



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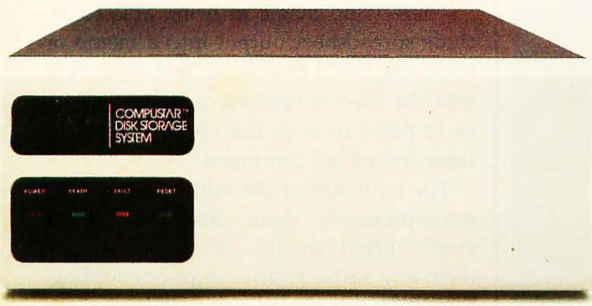

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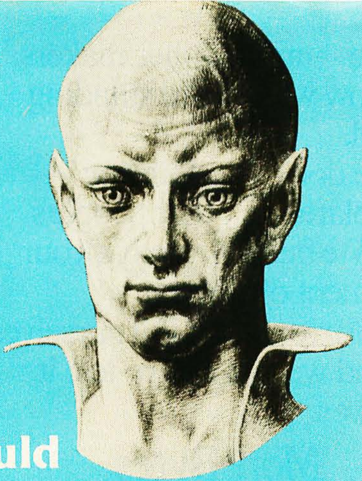

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dent. In other words, an editor edits; a word-processing program processes a file to produce text output. The future does not lie along the path of integrating these two functions, as with 1-2-3 or MBA, but in separating the functions.

For example, in my editor, when I want to end a line, I should be able to press Enter. There should be no implication to a coupled word processor that Enter signifies the end of a paragraph. If I want to signal the end of a paragraph, I'll signal that in the file I'm editing, using a word-processor command, as a separate step.

There is no magic in being able to include spreadsheet output into a memo or book chapter. I should be able to copy it into the file I'm creating with my editor, or to point to it, in the file, by means of some imbedded command.

The structure of the editor output, the word-processor input, and the spreadsheet output should not imply among them any native relationships or coupling. I use such uncoupled software in my job; there is no reason that it cannot be developed for microcomputers.

In this light, the new advances may signal greater sophistication but not necessarily greater ease of use. A desktop manager is only a sophisticated analog for being able to copy one file into another.

Robert C. Maegerlein
218 Watchung Ave.
Upper Montclair, NJ 07043

On Structured Programming

As a professional programmer and a structured-programming maven as well as the owner of an S-100, 8-inch CP/M personal computer, I have watched the language diatribes fly back and forth with great interest. Although I realize my status as a high priest will leave my opinions open to suspicion, I wish to make a few points about programming and languages in general.

Despite anything else that may have been uttered in haste about structured programming, the primary lessons of a structured approach are to figure out what you want your program to do, what type and form of data it is intended to input and output, and how your program will interact with its user, *before* you write a single line of code.

The software designer usually uses some kind or combination of hierarchical tree chart, Verner-Orr diagram, and/or

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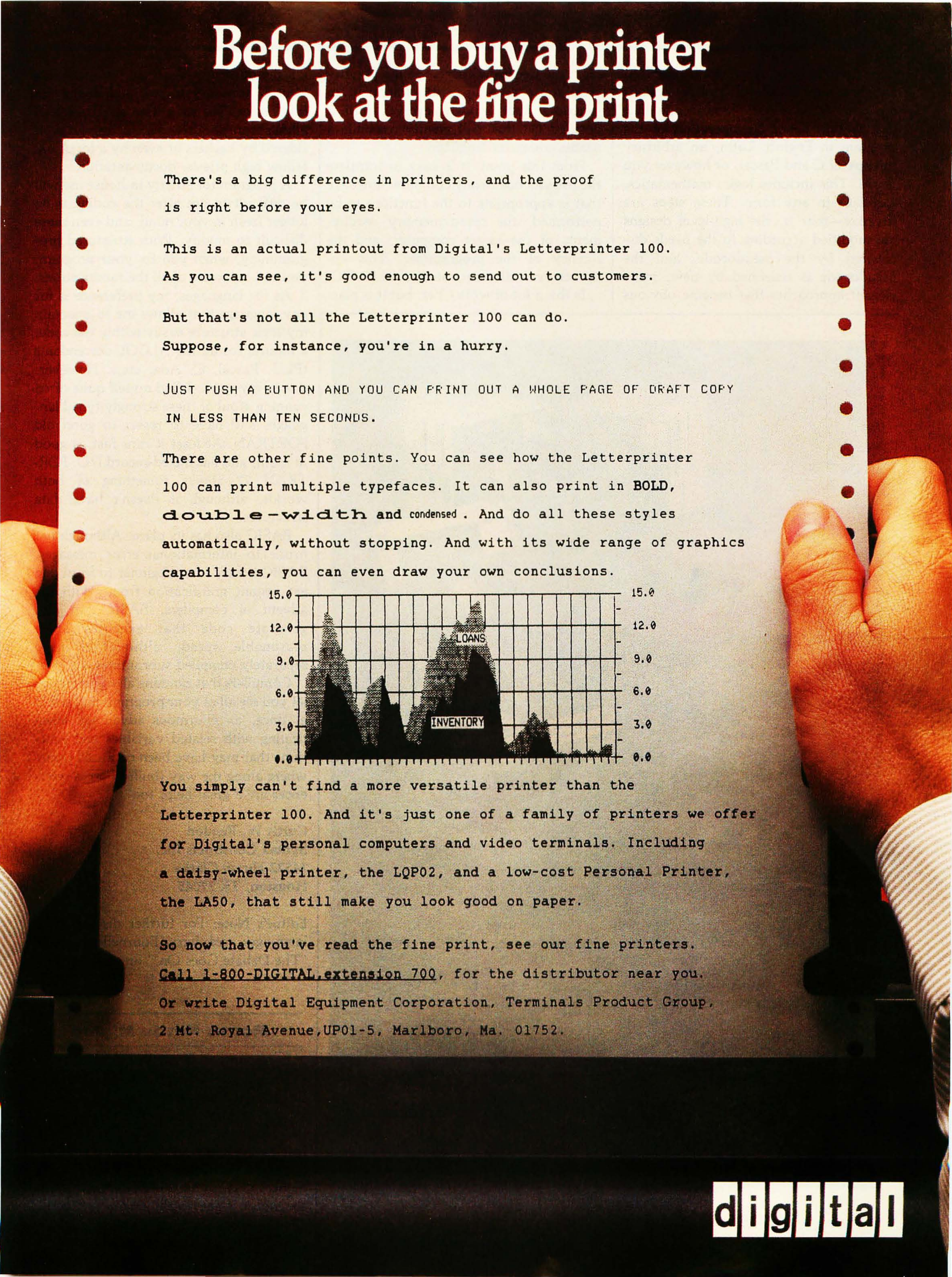
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flow chart to develop program function, and these very high-level, abstract designs are then translated to pseudocode that describes in detail the operation of the program in English, Latin, an arbitrary mixture of C and Pascal, or however you desire. This includes logic, mathematics, and I/O in any form. These steps are iterative—that is, the high-level designs are modified according to the needs discovered by the pseudocode, and the pseudocode is redefined by new, more elegant approaches that become obvious from the tree/flow charts. So the pseudocode starts as a simplistic statement of functions that quickly evolves into a detailed list that will greatly resemble a usable computer language.

From this point, it is easy to translate the pseudocode to any computer language that is appropriate to the functions to be performed, the speed/memory requirements of the target computer, and the fluency of the programmer. This approach even allows for structured BASIC.

Is this a lot of work? Yes, but it is placing the burden at the front, so much less time is necessary to test and debug the final result. The structured approach also allows for another benefit rarely considered by hackers or even by a lot of my fellow high priests: documentation.

A program for strictly in-house use will be difficult to use after the coding is no longer fresh in your mind, and even more difficult to modify. With structured programming, when you fix your program, you can be aware of all the ramifications.

As for languages, my preference is for any language that allows me to maintain my logic structure easily within the code, a natural for all the ALGOL descendants (PL/I, Pascal, C, Ada, etc.). However, due to my work, I find myself quite often running afoul of these strongly typed languages and have to resort to good old FORTRAN. At least it runs fast, is good at math, and has mixed-record I/O. FORTRAN 77 allows something of both worlds, although it doesn't have data structures.

BASIC also has its place. Although not prone to informational error messages, BASIC is easy for a beginner to learn and get instant gratification from. With the advent of compilers, BASIC can also generate code that executes at a reasonable speed, although I need separately compiled subroutines.

Compilers that examine all of your code let you see all of your programming errors at once, an enormous advantage when dealing with related variables and functions that may have been confused somewhere along the way (built-in cross-references are a great help, too).

Curtis W. Rendon
Syntax Constructs Inc.
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Editor's Note: For further discussion of languages, see Jerry Pournelle's article, "The Debate Goes On," on page 312.

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Mouse: Not So Mighty

In response to Gregg Williams' editorial ("The New Generation of Human-Engineered Software," April, p. 6), the mouse of Lisa, Visi On, and their predecessor, the Xerox Star, is a truly fascinating hardware device, and on those few occasions that I have seen these devices in use, I have been impressed. But the mouse is not revolutionary, and, as its

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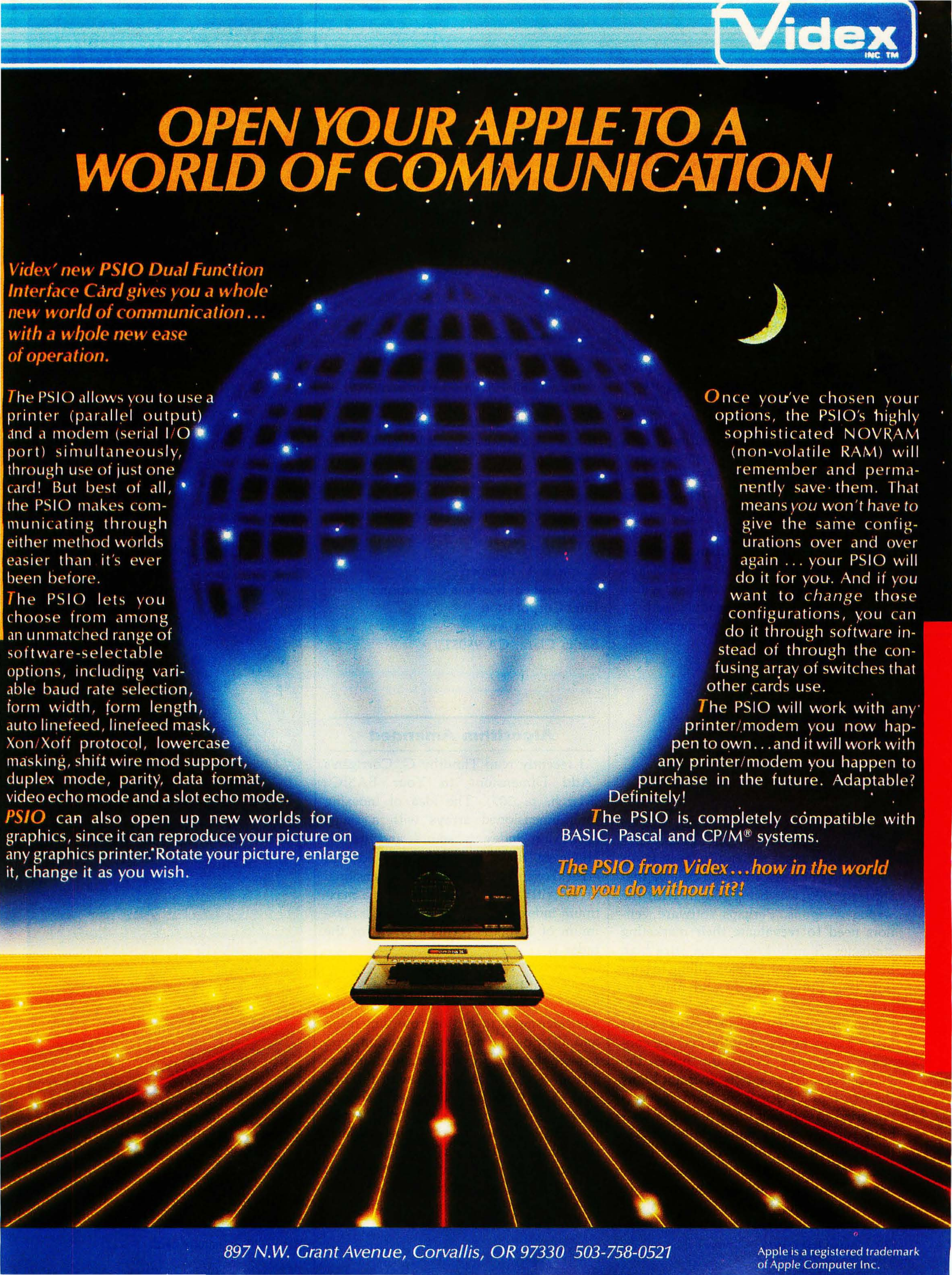
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name suggests, it is really nothing more than a rodent. Its functional predecessor was the light pen. Some years ago, light pens were fashionable devices for selecting a particular function, and they are still in use. But displays attaching light pens had to have an appropriate phosphor, and they were not as easy to program as function keys. About the same time, touch-sensitive screens were introduced, and they are still used in applications such as online catalogs in libraries; here, too, however, programming appears to be the chief stumbling block.

If the name of the game is "ease of use," the industry would be far wiser to develop touch-sensitive displays than mice. Because a display has no moving parts, it is likely to prove more durable than a mouse. And a finger placed on a display screen does not require additional desk space, as a mouse does. If an executive were having an office conference, don't you think he might rather touch his screen a couple of times than roll a mouse around his desk pressing buttons on it?

There are, obviously, many considerations at work in the development of new products. My bet, simply stated, is that the mouse is not a viable product. At best, it will limp along like bubble memory.

John P. Rash
President
Acorn Data Ltd.
611 W. 111th St., Box 57
New York, NY 10025

The High Cost of Software

I certainly don't pretend to be in favor of the theft of software, but I believe that software piracy is being fought with the wrong weapons. Perhaps software vendors need to reevaluate their marketing strategies. Simply keeping the price high because the market appears willing to support it is both a greedy and naive approach.

Vendors are not solely to blame for high prices. I believe that the average consumer pays the exorbitant prices demanded because he simply does not know the worth of a piece of software. If someone tried to sell that same person a textbook for, say, $300, he would laugh. Yet the textbook may easily represent more hours of labor and may require more years of experience on the subject area to write. In addition, the book may not enjoy as large a market as a good piece of software does.

I don't begrudge companies a fair profit, but I do object to exploitation. I think that if anybody is being "ripped off" in this industry it is we the consumers, not the software companies. Perhaps they are the pirates.

P. J. Lenk
2505 David Ave.
Pacific Grove, CA 93950

New, Improved Compiler

Jay Freeman's letter (April, p. 20) in regard to Intel's FORTRAN-86 version 1.0 points up some known difficulties with that past version of our compiler. The release of the FORTRAN-86 Compiler, version 2.1, that is currently being shipped to customers corrects bugs found in the previous version as well as provides new features.

Kenneth A. Pomper
Development Systems Operation
Intel Corporation
3065 Bowers Ave.
Santa Clara, CA 95051

Algorithm Amended

I recently read Timothy G. Corrigan's "Add Dimensions to Your BASIC" (March, p. 307). The idea of indexing multidimensioned arrays with a single dimension index is sound and useful. However, the algorithm introduced is in error. For instance, for a two-dimensional array with a dimension X having a maximum index of XM, and Y having a maximum of YM, the formula given for the index is

$$I = X \times YM + Y$$

Considering X to be the row dimension and Y to be the column dimension, you can see that this formula produces indices I from 0 to YM associated with the first row (X = 0) of the matrix, as it should. However, the next element I that is produced (for the second row, first column, such that X = 1, and Y = 0) is also YM. In every case, the formula repeats the last index I for the last row element for the element that is first in the next row. Ob-

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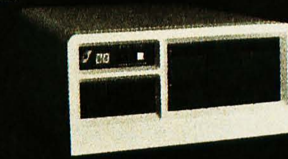

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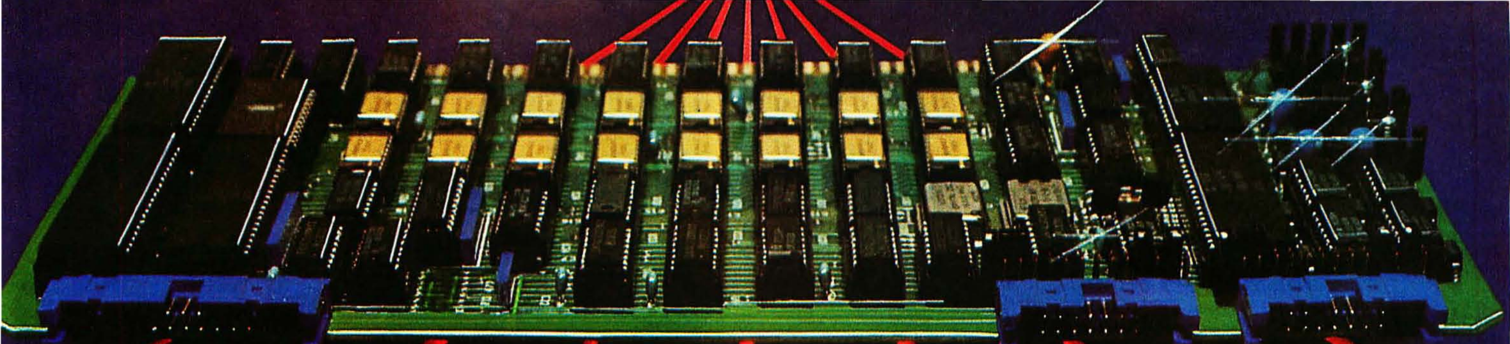

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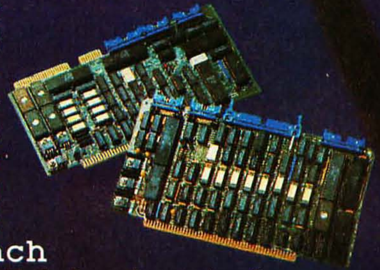

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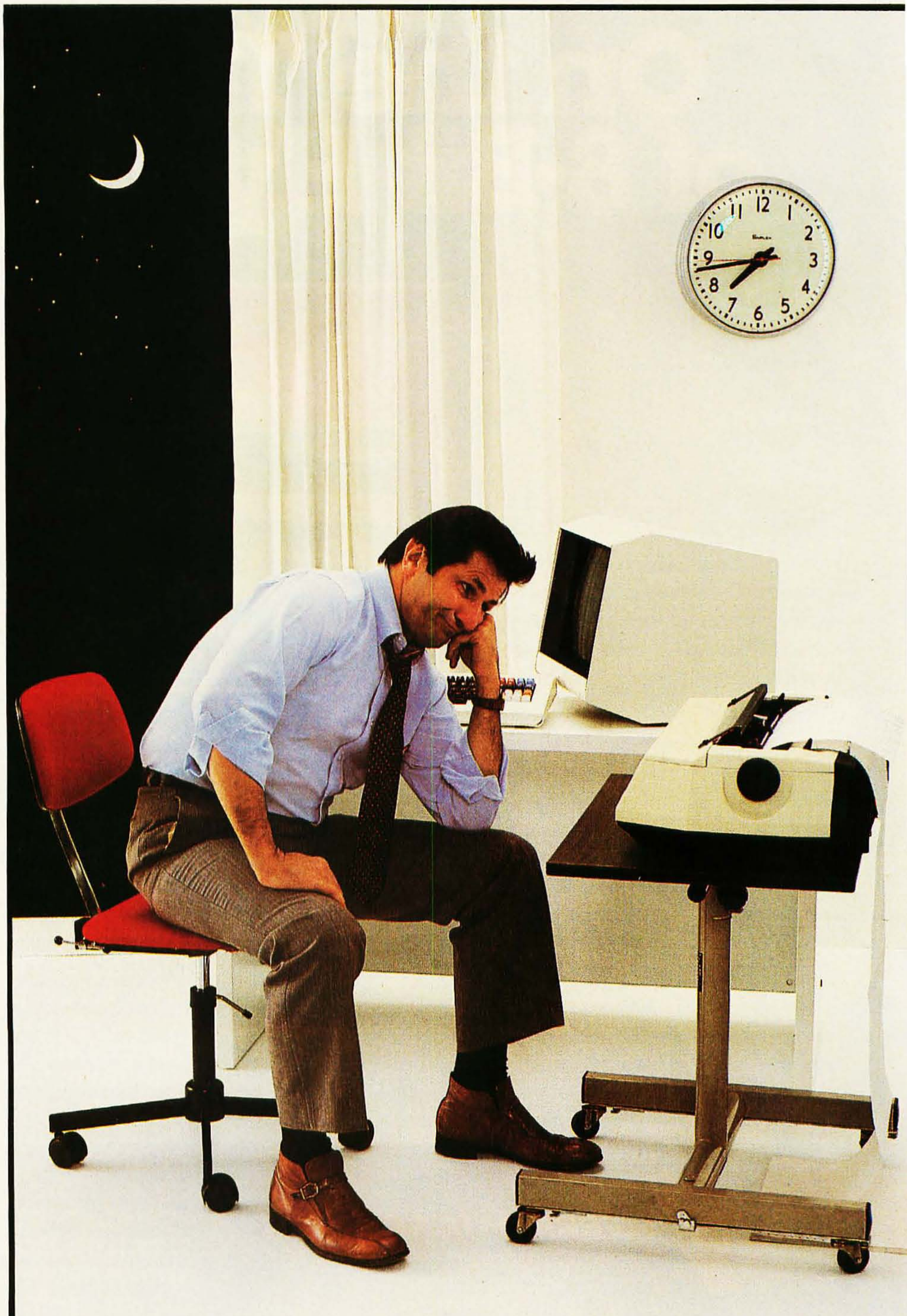

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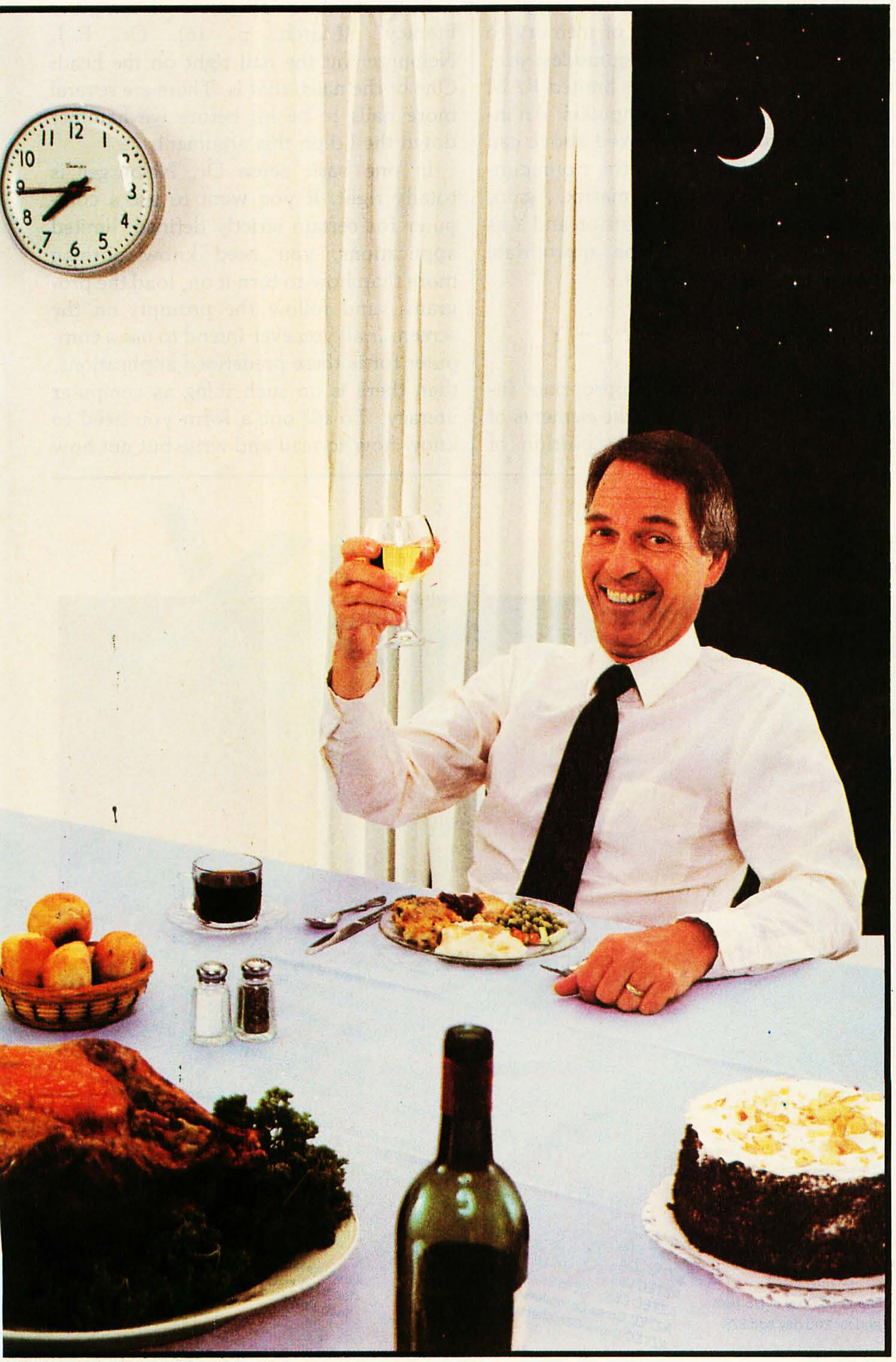

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viously the index I must refer to a unique array element to be of use. Perhaps an even simpler way to show that the formula is in error is to consider the two-dimensional problem of a 10(X = 0 to 9) by 5(Y = 0 to 4) array, for which Corrigan provided a BASIC program. You can immediately see that the maximum I obtainable from the prescribed formula occurs when X and Y are maximum and is 40, yet there are 50 elements in the array. The corresponding correct formula for the two-dimensional case is

$$I = X \times (YM + 1) + Y$$

The algorithm can be extended to a third dimension, Z, by modifying the procedure described by Corrigan. You must enclose the two-dimensional expression for I in parentheses and multiply by 1 plus the maximum value of Z, ZM, and add Z as

$$I = (X \times (YM + 1) + Y) \times (ZM + 1) + Z$$

This same algorithm can be used for any number of array dimensions just by repeating the process.

In addition, it might be mentioned that in many applications, especially in statistics, many square two-dimensional matrices that are encountered are symmetric, that is, the same elements are contained above and below the diagonal. An example is an intercorrelation matrix, which expresses the degrees of relationship between all possible pairs of variables. Traditional statistical software for mainframes has ignored this fact and stored the whole redundant array in memory; there was plenty of memory to spare. With matrices of even modest size, this is undesirable with the limited RAM available to most microcomputers. An index similar to that introduced above can be created to index only the nonredundant information in such a matrix. Again, assuming X as the row dimension and Y as the column dimension, the appropriate two-dimensional formula is

$$I = (X \times (X + 1)) / 2 + Y$$

Using this formula, the appropriate indices will be created for all the elements of the "bottom" nonredundant portion of such a square symmetric matrix.

John D. Morris, Associate Professor
Box 8143
Educational Leadership & Research
Georgia Southern College
Statesboro, GA 30458

"A More Powerful Pencil"

In his letter on "the myth of computer literacy" (March, p. 16), Dr. E. J. Neiburger hit the nail right on the head. One of the nails, that is. There are several more nails to be hit before we hammer down the lid on this argument.

In one basic sense Dr. Neiburger is totally right. If you want to use a computer for certain strictly defined, limited applications, you need know nothing more than how to turn it on, load the programs, and follow the prompts on the screen. If all you ever intend to use a computer for is these predefined applications, then there is no such thing as computer literacy. To fill out a form you need to know how to read and write but not how

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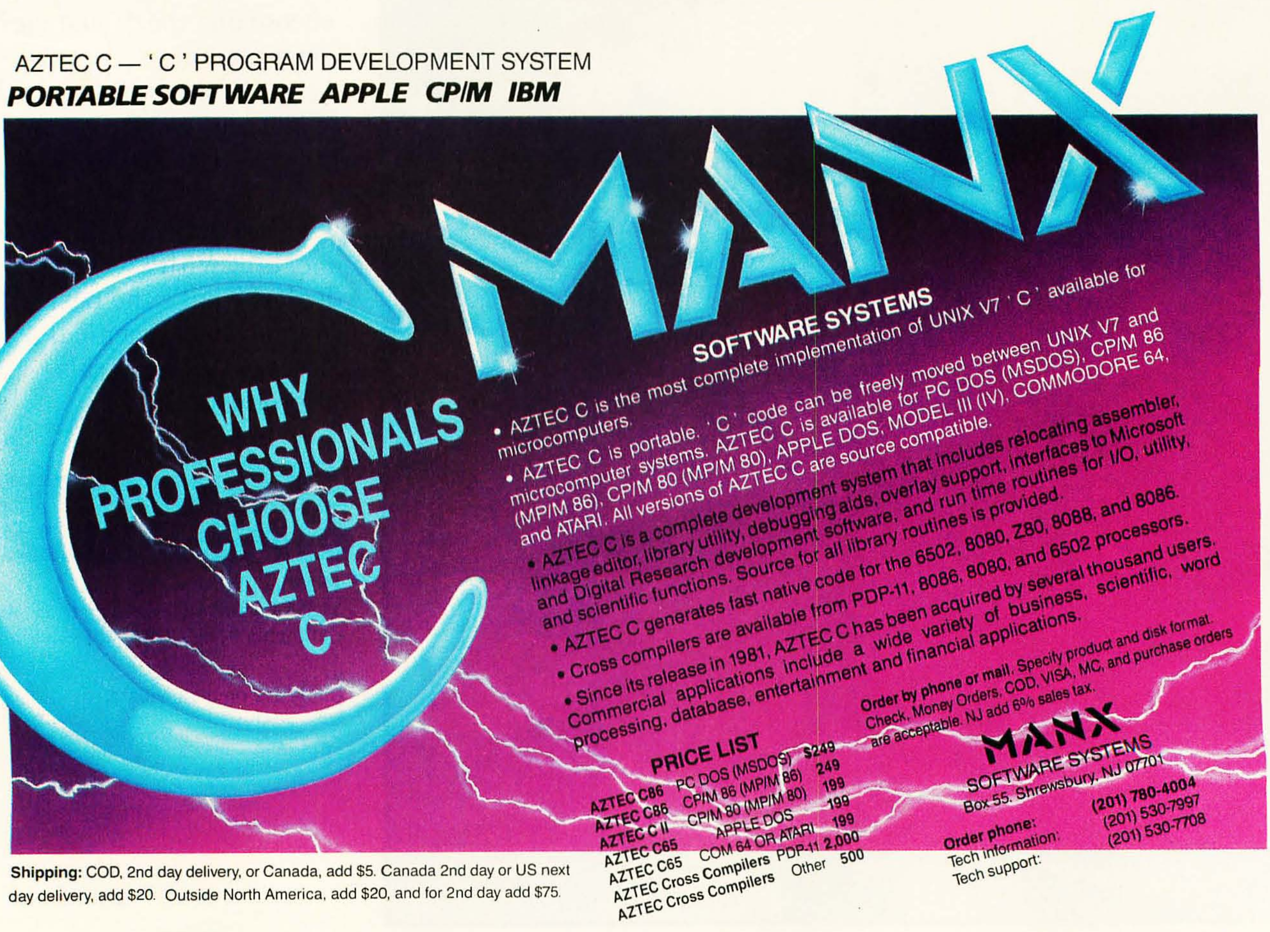

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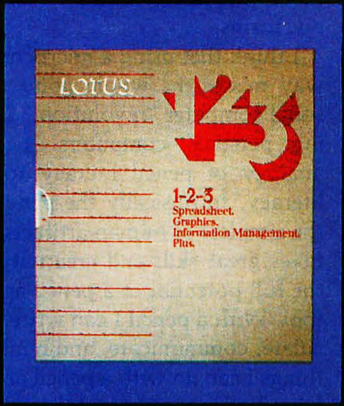

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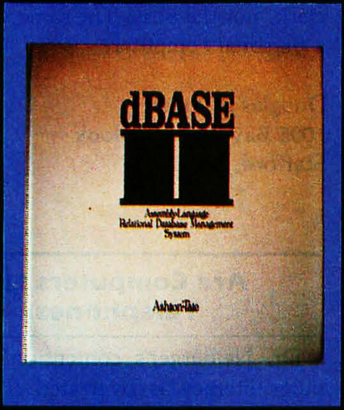

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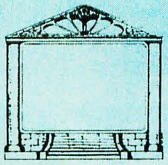

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to think. Using a computer only for predefined applications is similar to filling out forms.

I think that using a microcomputer this way misses the whole point of the personal computer "revolution." In considering personal computers, I prefer the analogy of pencil literacy to telephone literacy. Intrinsically the pencil is one of the simplest of human artifacts, and yet it takes great skill and creativity to realize the full potential of a pencil as a personal tool. With a pencil I can write, draw, calculate, communicate, and remember. The things I can do with a pencil are limited to what I can imagine and the skill I have in carrying through my imaginings. A personal computer for me is a more powerful pencil.

My point is that there is such a thing as computer literacy. I don't propose that to be computer literate all of us need to become programmers. I do believe that we need to learn to understand the scope of the tool we are dealing with and how to use it creatively, not by rote. And to "use" means just that, to invest the time and effort to learn the commands and procedures of packages such as database-management systems, spreadsheets, and word processors.

Computer literacy means learning how to use and exploit the tool that a personal computer is. If you use your pencil just to copy over the accounts, you'll be the clerk, not the boss. The same is true with a personal computer.

Douglas F. Yriart
1005 Bayview Overlook
Stafford, VA 22554

Are Computers Like Telephones?

Dr. Neiburger's contention that computer literacy is overrated (Letters column, March, p. 16) is well taken and almost convincing. Those of us who work with microcomputers and spend a lot of time thinking about them do seem to be caught up in an imbroglio of expensive gadgetry and words that have capital letters stuck oddly in their middles. Like any new toy, personal computers have been subject to an intense media hype that tends to throw the whole issue out of perspective.

But computers aren't like telephones at all, and to reduce operating a computer to merely turning it on and following the in-

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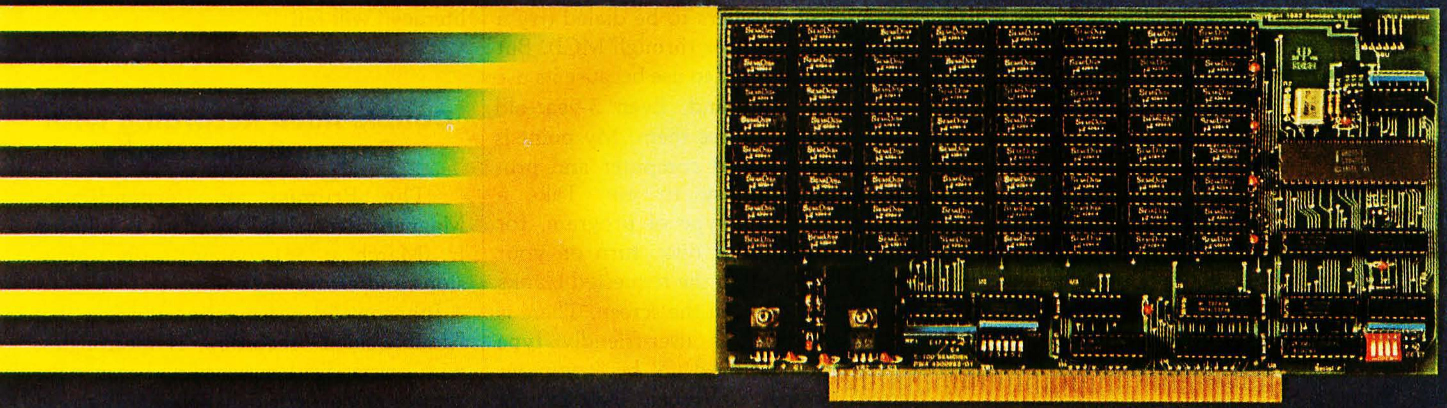

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structions on the screen is a gross oversimplification. If this were the only trick, there would be no manufacturers' support services, no user groups, no manuals to teach us how to read our manuals. Even a novice *should* have some insight into the workings of the machine, and that means getting a sense of the mathematical and electrical properties involved and learning the terms that describe them. A user who seeks only to snap the disk into the drive and have his or her problems magically solved will probably never feel confident about the computer or use it creatively.

Many people view computers with skepticism and deny their usefulness—at one time or another we've all received someone else's bank statement. But when a computer is working properly it can help enormously. When it is not working properly, it is better if the person punching the keys has a vague idea of how to clean up the mess.

Terry Nasta
Senior Editor
Computing Physician
515 Madison Ave.
New York, NY 10022

E. J. Neiburger replies:

Mr. Nasta's comments on my letter are well taken. It is true that many computer systems and software are not as easy to operate as a telephone, but that is due to poor design or equipment limitations (lack of memory for help screens, etc.).

The telephone is a complicated instrument with many buttons, signal tones, and series of numbers to be dialed (try a long-distance number through MCI). But the telephone is easy to use because its use is *easy* to understand. Even 3-year-old children routinely use them. My point is that a well-designed computer and program are also easy to use. Take a templated Visicalc type of program, for example. Load your disk, turn on your computer, and fill in the requested blanks when they appear on the screen. There is no problem with this "user friendly" type of program. You need not be "computer literate" to use it. Visicalc may require knowledge of a few commands gleaned from reading a manual, but no big effort.

Conversely, many programs may require considerable effort in order to run, but this problem can usually be solved with better programming and design.

With rare exceptions, I believe that a truly good program and computer system should not require any complicated manuals or other documentation. Like the telephone, it should be designed to function well in the hands of the novice. Those firms that develop systems along this line will thrive. Those that hide their deficiencies under the buzzword "computer literacy" will fail.

Double-sided Recording with Perpendicular Media

"The Promise of Perpendicular Magnetic Recording" by Clark E. Johnson Jr. (March, p. 56) contains serious omissions and errors of fact.

Johnson did not mention the fact that "double-sided" recording is meaningless with perpendicular recording because the recording magnetic field necessarily passes *through* the medium. Of course, the increased density made possible with perpendicular recording makes double-sided recording less advantageous. Nevertheless, the disadvantages of double-sided recording are still present and may be magnified.

Most prominent of these presumed disadvantages is the fact that the read/write head, instead of being one small component, must have two parts, on opposite sides of the medium, and that these two parts must always be accurately aligned. This condition is desirable but not indispensable with double-sided longitudinal recording. Furthermore, the length of the magnetic flux lines, which must always form a closed loop, is vastly greater with perpendicular recording because the lines must pass around the edge of the medium rather than remain within the head and its supporting structure. These long flux lines require low magnetic reluctance in the access mechanism to enable the detecting circuits to pick up the changes in magnetic flux when reading and to enable the drive circuits to generate appropriate signals when writing.

Johnson also mentioned the possibility of using perpendicular recording of audio signals and the applicability of data compression to such recordings. That may be true, but his example betrays a gross unfamiliarity with musical quality. He asks, "Why record all 800,000 bits of data for a soprano who sustains the same note for an entire second?" The question is, what constitutes the "same" note? All vocalists and many instrumentalists—notably violins

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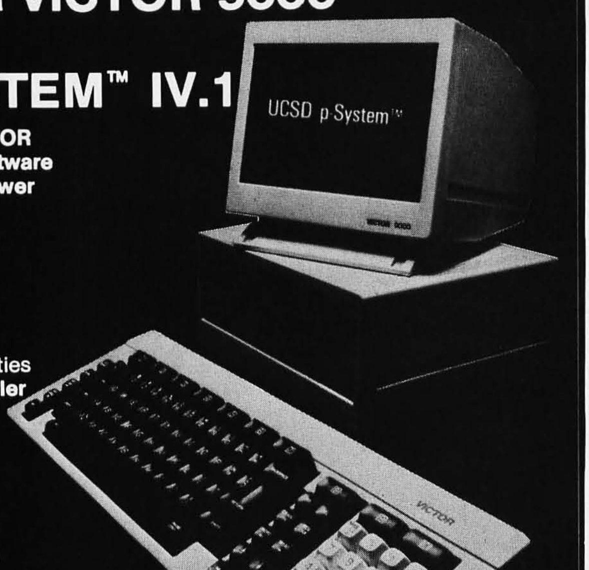

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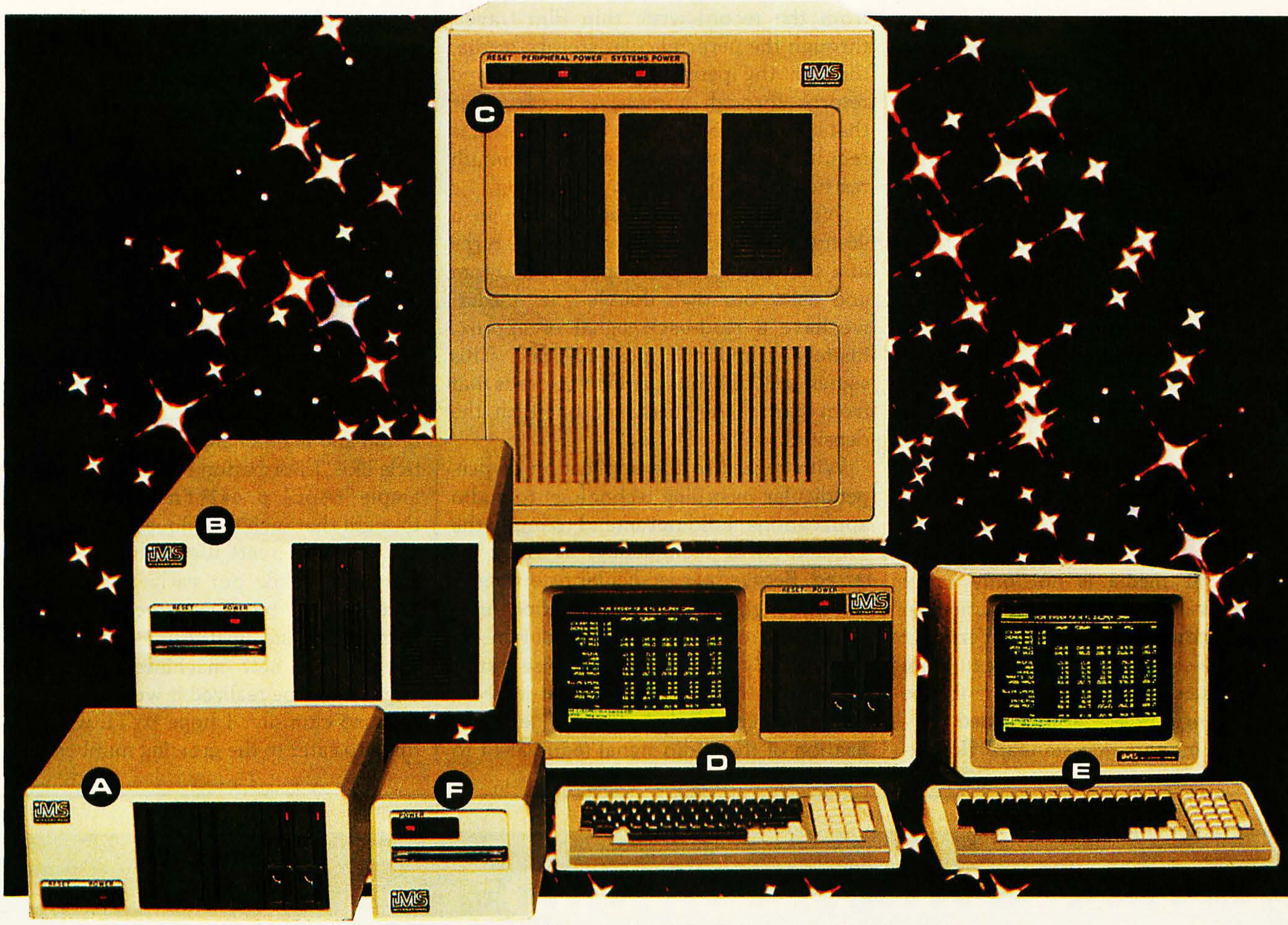

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and other stringed instruments—introduce tiny changes of pitch and not-so-tiny changes in volume when sustaining a note. These modulations constitute the difference between a musical note and a steam whistle. Anyone listening to a performance by a would-be musician who does not use them finds the experience rather unpleasant. A recording of a performance would necessarily include these modulations, making the compression of data considerably more complicated than Johnson implies, if not impossible.

Wallace B. Riley
309 Garces Dr.
San Francisco, CA 94132

Clark E. Johnson replies:

Contrary to the opinion Riley expressed in his letter, double-sided recording with perpendicular media is not only fairly straightforward but easy to implement in a practical configuration. We at Vertimag use a single-sided, single-pole head shim that provides the advantages of the Iwasaki single-pole, double-sided approach but mounts in a standard floppy-disk head button configuration. The flux from the record/write thin film travels through the perpendicular storage media, through the permalloy back layer, and returns through a massive ferrite piece that connects to the shim. No alignment is required other than the normal azimuth restrictions of high-density recording.

With such a head configuration in a 96-turns-per-inch disk drive using 50 turns at a standard disk-drive speed of 300 rpm and using our own double-layer media, we have a read-back signal of approximately 1 millivolt peak-to-peak. This signal, at 30,000 bits per inch, exceeds that from particulate media at one-fifth the density.

With regard to the application of perpendicular recording technology to audio applications, I did not intend to imply the elimination of redundancy, as Riley inferred. Because perpendicular recording in its most efficient implementation uses saturation recording, one can obtain extraordinarily high signal-to-noise ratios by pulse with modulation—what is essentially a binary digital signal. The quantization of the audio signal (equivalent to the number of bits in a conventional digital audio system) is limited only by the atomic columnar structure of the media itself. This limitation is equivalent to approximately 400,000 bits per inch.

Information Hiding

First it was hacking, then structured programming, and now information hiding. As a programmer who has outgrown the need to produce arcane works of twisted genius, I can appreciate the innovations that facilitate ease of implementation and maintenance. When I see an article like "Information Hiding: A Brief Example" (April, p. 442) I'm gratified by the thought that such techniques will free programmers to create useful, higher-quality software. While our early methodology was justified by slow processors, small memories, and inefficient mass-storage devices, the new machines' capabilities might never be realized if we were to continue so clumsily. I hope BYTE will continue to cater to the growing number of us

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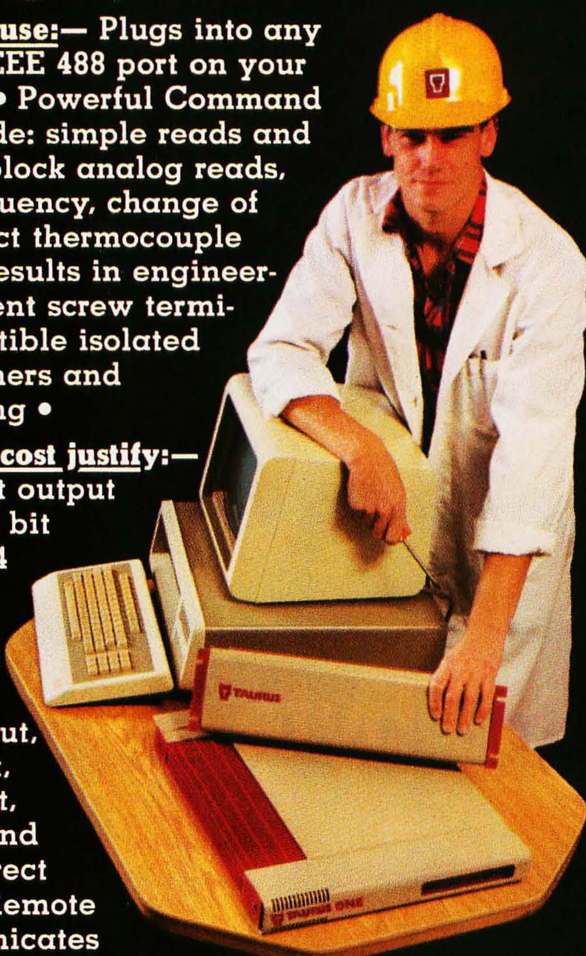

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2. Place the Disk II controller card in slot 7.
3. Turn the Apple IIe on and press the C key once while the system is booting up.
4. A prompt will appear: "ENABLE CORVUS IN SLOT 6 (Y/N) :"; press Y and RETURN.

Steps 3 and 4 are carried out each time the system is turned on. These steps allow Apple Writer IIe to work with a Corvus drive that has been formatted with DOS 3.3 volumes.

Paul Lutus, President
Walden Software Inc.
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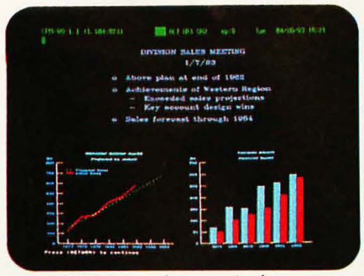

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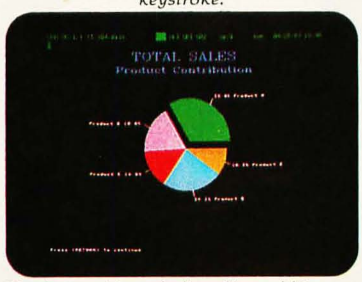

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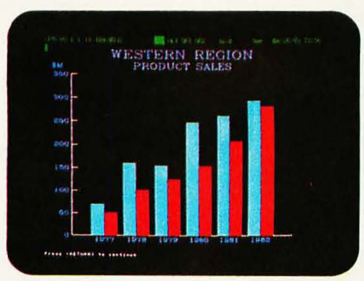

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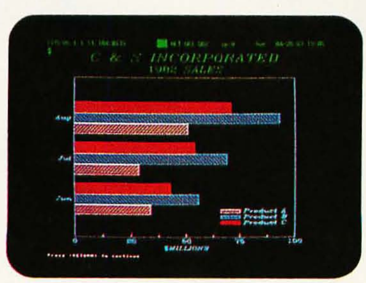

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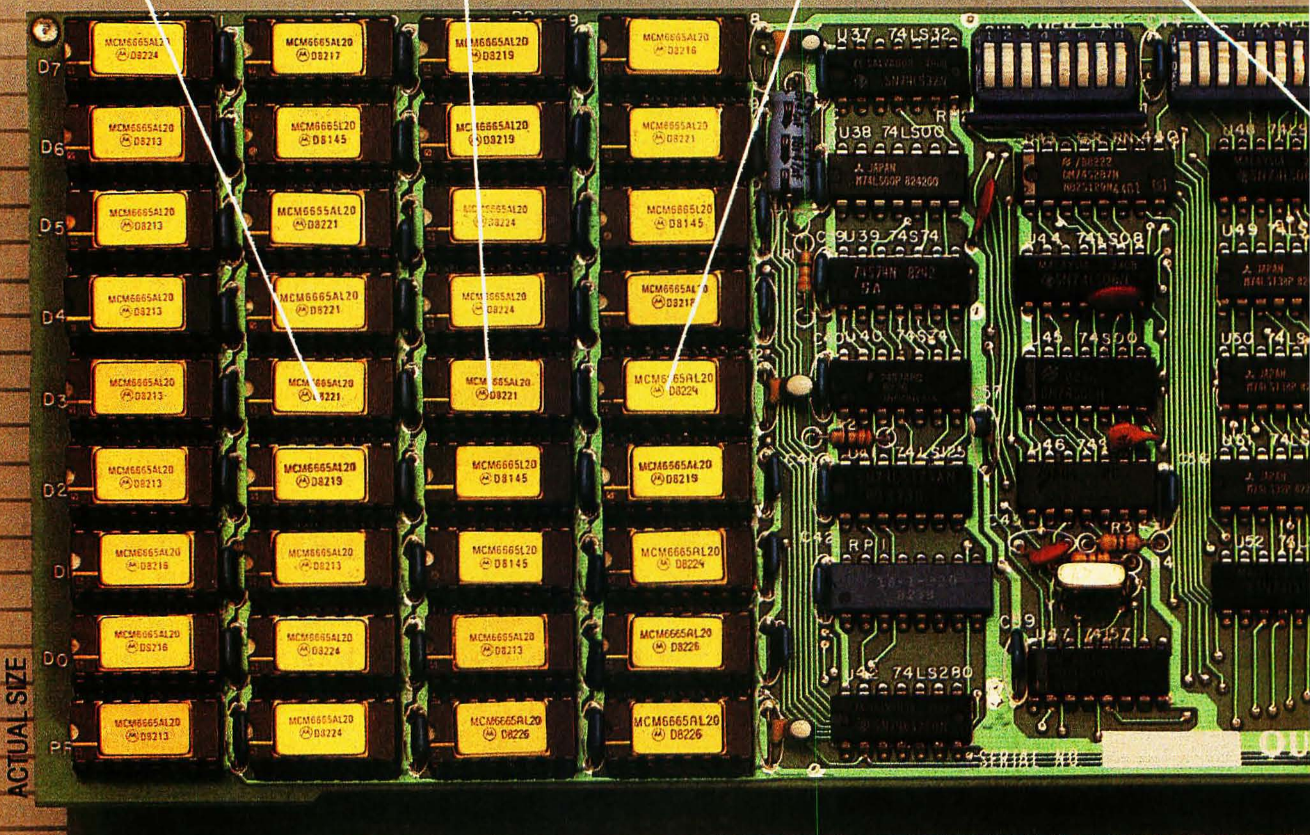

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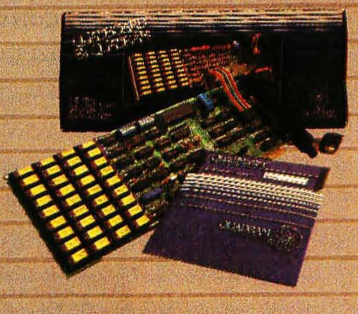

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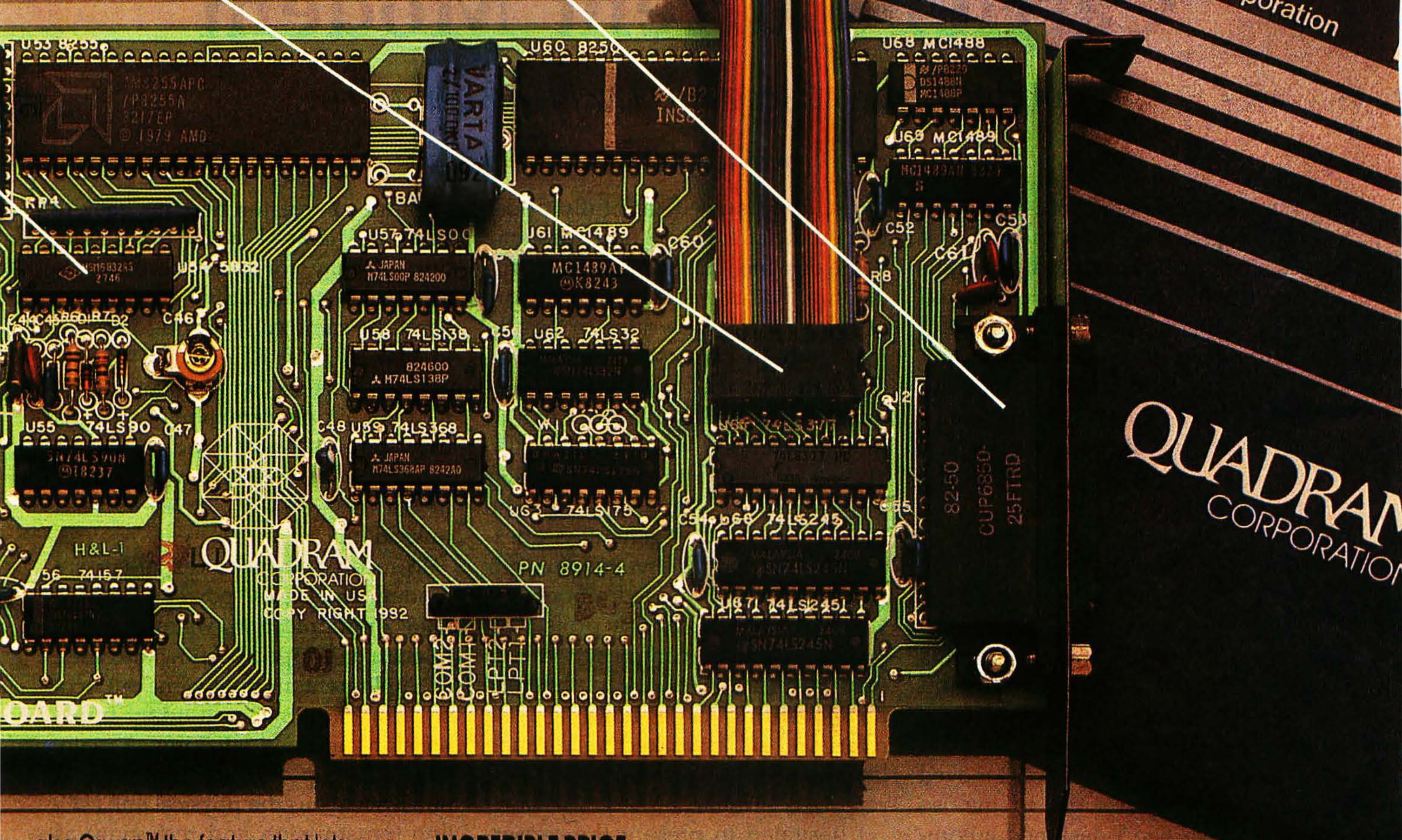

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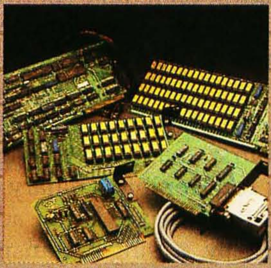

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Build a Power-Line Carrier-Current Modem

Communicate using electrical power wiring

by Steve Ciarcia

"Jiggle the printer cable, Jeanette."

My assistant reached through the rat's nest of wires behind the computer and grabbed the one connected to the printer. As she moved it, I identified its other end from my cramped vantage point beneath the workbench and pulled it through a slot to attach it to my latest project. I was glad that what we were doing would keep us from having to run cables around the Circuit Cellar so often.

I have long had video terminals, printers, and other data-communicating equipment located at various places in the Circuit Cellar and around the upper stories of my home (see reference 3). Eventually the pain of rerouting cables whenever I moved a peripheral device got to me, so about a year ago I designed a communication system that would save having to string new wires every time. My system revolved around a *carrier-current modem,* which operates in much the same manner as the familiar telephone modem but sends its signals over electrical power wiring instead of over a telephone line.

After I pressed the carrier-current modems into service (with a little help), they served faithfully and I turned my attention to other projects, some of which have appeared in this column. But as of late more and more of my readers have written to me asking for help on how to send data through the AC power line. Apparently the widespread use of and media attention to the BSR X-10 Home Control System and similar products have given many people the idea of using the generally unexploited carrier-current modem for communication. Indeed, about five years ago I published a project on building a remote-control system that communicated through the AC power wiring of a building (see reference 4). It worked very much like the BSR X-10 as a carrier-current remote controller.

I hesitated to present the carrier-current modem as a Circuit Cellar project until now because I feel there is more to general-purpose carrier-current communication than meets the eye.

Simple on/off remote control is different. In most control applications, the communication is generally half-duplex or simplex; the transmission is limited to an intermittent tone or pulse burst that merely triggers a specific receiver into a binary control state. If the receiver is not activated properly by a single transmission because of interference, it's easy to send the control burst more than once. (Many computer control systems that use the BSR X-10 receivers send the same control code 10 times to make sure it is received.) But in general-purpose serial data communication, proper reception of every bit may be necessary, and errors in reception of the data may negate the usefulness of carrier-current operation.

To successfully use a carrier-current modem and the AC power wiring for data communication, we must either tolerate a dropped bit now and then or implement an intelligent protocol of error checking, redundant transmission, and handshaking. A really dependable power-line communication system has the physical link (AC-line transmission and reception) as only one of its components.

I was going to wait until I had perfected the control and error-checking protocols for use with the carrier-current modem, but the increasing interest indicated by my mail suggested that many experimenters might benefit from building a simple carrier-current modem; at least the physical part of the connection could be set up, even if the protocols and software are not ready.

This month's project, a modem for data communciation using the AC

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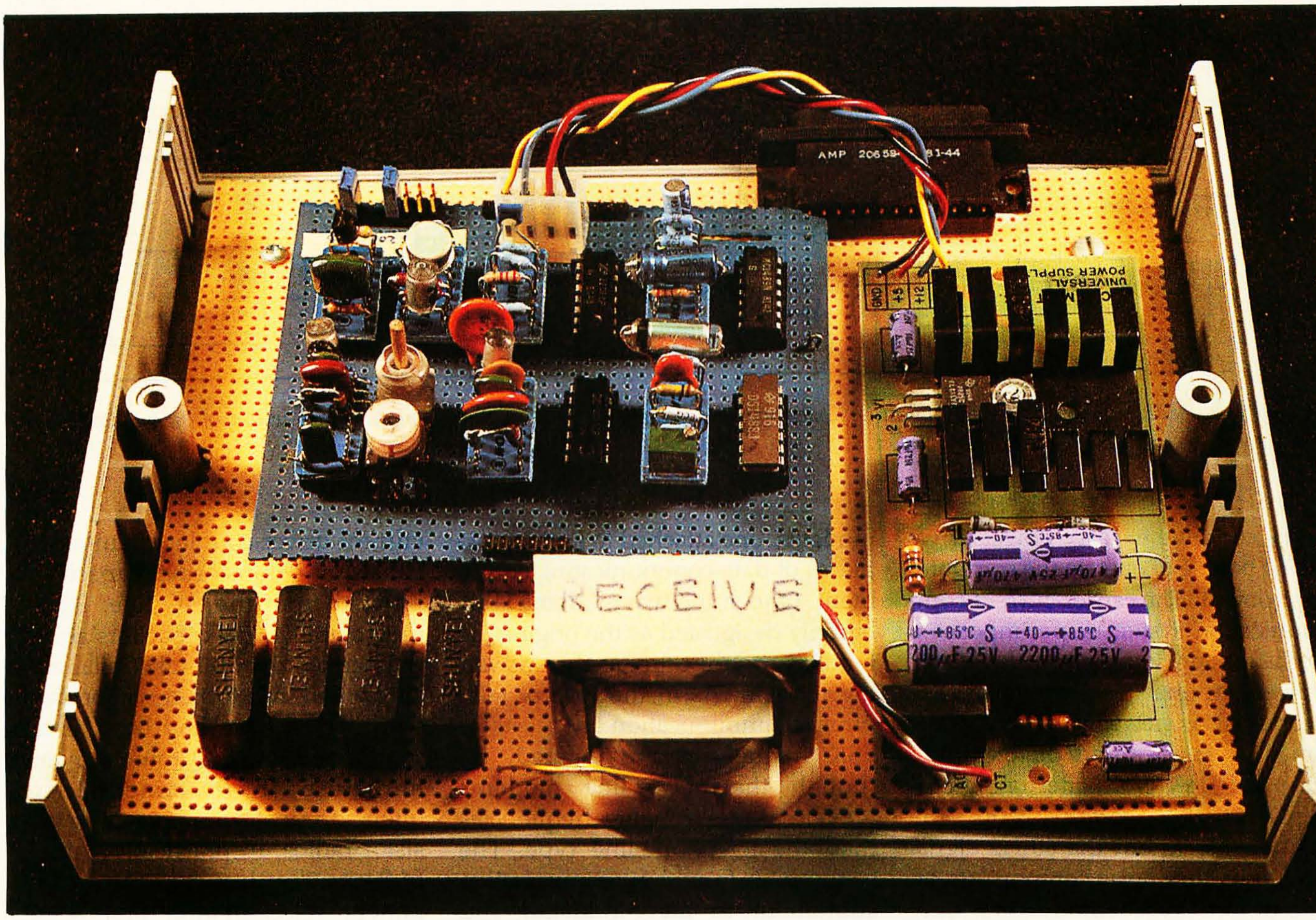


Photo 1: *Prototype of the Circuit Cellar CCM-1 carrier-current modem, which transmits serial data over the AC power line at 1200 bits per second. When in originate mode, the modem transmits mark signals at 90 kHz and space signals at 95 kHz; the answer mode transmits marks at 80 kHz and spaces at 85 kHz. The receive unit, shown here, differs from the transmit unit only in the frequency-selecting passive components.*

power line, is mostly an analog circuit. Successful operation of the modem, therefore, depends much more on tweaking and tuning the components than do digital computer-related projects. I am presenting this two-chip modem chiefly to discuss the principles involved, with some emphasis on selecting components for this application. Because the principles are susceptible to broad application, this knowledge should also be useful in understanding other modem designs as well.

All Modems Are Not Alike

The modem, named after a contraction of the words "modulator" and "demodulator," is a fairly common piece of computer equipment. You've probably seen modems built for sending data over telephone lines, and you may have read my March Circuit Cellar article about a low-cost modem (see reference 2). A modem allows two pieces of digital equipment to communicate with each other over long distances without having a direct hard-wired connection between them. With a telephone modem, the telephone lines form the communication path.

Modems of the usual type translate the voltage levels of the digital input signal (usually RS-232C levels) to tones at two frequencies, one of which signifies a logic 0, the other, a logic 1. The process of shifting the frequency of the output tone as the logic levels change is called *frequency-shift keying*, and the modems are called frequency-shift keyed, or FSK, modems.

To allow communication in two directions at once (full-duplex mode), rather than in only one (half-duplex), two pairs of frequencies are used, avoiding conflict when both ends of the connection talk at the same time. (By convention, one pair of tones is called the "originate" set, and the other is called the "answer" set. The two terms merely signify which set of frequencies each unit is using; no implication is intended regarding the content or origin of the data itself.) For compatibility, modems are built to adhere to certain standards of operation; the most common system in North America for low-speed modems was first used in the Bell System's Model 103 modem, so Bell-103-type modems abound.

Carrier-Current Systems

The AC power line is similar in some respects to the telphone line. One similarity is clear: we can send data through the power line by using an FSK modem.

Obviously, in addition to the data we want to transmit, the power lines

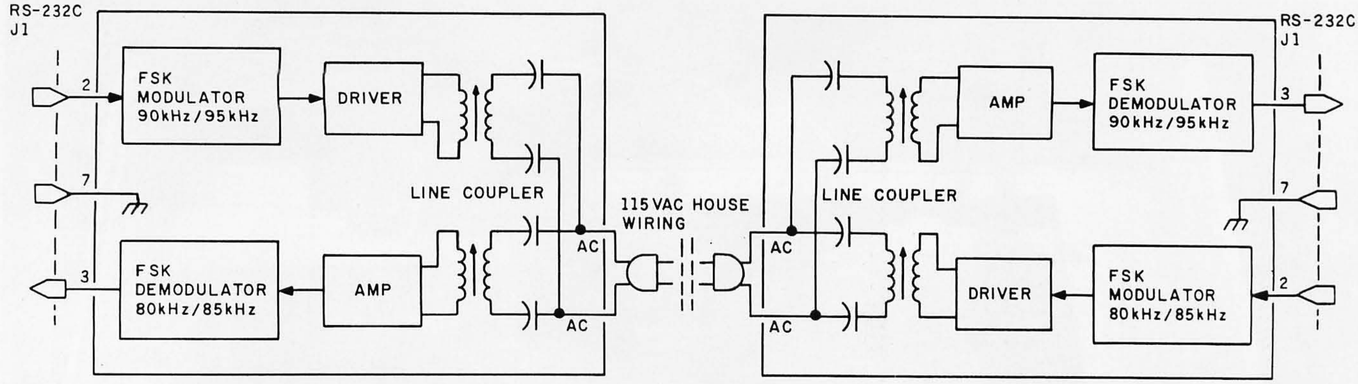


Figure 1: *Block diagram of a data-communication system employing carrier-current modems. The AC power wiring of the building is used to carry the frequency-shift-keyed transmission.*

must continue to carry power or we won't be able to operate the computer equipment. The carrier-current communication system superimposes a high-frequency signal on the 60-Hz power-carrying signal. On an oscilloscope, this is viewed as an additional small voltage carried on or riding atop the 115-V (volt) alternating current. At the receiving end, the modem filters out the 60-Hz signal and any other noise components on the power line, demodulating only the transmitted frequency. Unfortunately, the power line sometimes has an impedance less than 2 ohms, along with thousand-volt noise spikes that make it a hazardous environment and a less-than-optimal communication medium.

There is a price to be paid for the simplicity of this communication system. Unlike the complex digital carrier-current systems, which transmit around the zero-crossing interval of the power signal, the analog FSK carrier-current modems are more sensitive to line peculiarities and noise. However, the digital species is much more complex, and after all, my intention was to present a build-it-yourself project. Learning a little black art for the sake of simplicity can't hurt.

Carrier-Current Modem Circuit

Figure 1 is the block diagram of a carrier-current modem, which consists of three basic components: modulator/driver, amplifier/demodulator, and AC-line coupler. The simplest usable system consists of two modems, one attached to each of two pieces of data-communicating equipment. One of the two modems is arbitrarily designated as the originating modem and the other as the answering modem. As in the case of telephone communication, two sets of FSK frequencies are defined, although the power-line modems operate at much higher frequencies than the telephone-line type. The connections from the communicating equipment to the modulator and demodulator on each modem are through an RS-232C DB-25 connector. The driver and amplifier sections are in turn connected to the AC line through the coupler, the crucial component.

In a direct-connect telephone modem, the coupler is usually a 600-ohm isolation transformer, and the characteristics of the line are well defined. But in a carrier-current modem, the coupling transformer is very often a tuned circuit selected to resonate within the passband of the FSK tones to improve the signal-to-noise ratio in this particularly noisy environment. While tuned couplers are not aways used, most carrier-current driver circuits do employ them to increase the transmission range and receiver selectivity. For most experimenters, the driver and coupler are the hardest sections to construct because so much depends on selecting, balancing, and adjusting the components.

Taming the AC Line

Figure 2 shows two typical carrier-current driver-coupler circuits. Both consist of a transformer capacitively isolated from the AC line; 0.22-μF (microfarad) 600-V capacitors are recommended. Any 0.1-mH (millihenry) slug-tuned transformer will probably work, but I have had best success with standard low-Q (low-resonance) miniature IF (intermediate-frequency) transformers used in transistor radios. In practice, the circuit of figure 2b is less sensitive to component selection and more easily tuned.

If you have any doubts about whether a particular transformer will work, a few brute-force tests can help you tame the AC line and give you the confidence to build the rest of the modem circuit. *Just remember that working directly with the AC power line is dangerous if you aren't careful.*

Begin by building two couplers, one driver, and one receiver, using the component values and circuit layout in the schematic diagram of figure 3. (I'll get around to discussing it shortly.) Temporarily apply power to the driver section and attach it (carefully!) through its coupler to the AC line. The receiver should be powered and connected through its coupler across the AC line at some other nearby location.

Use an oscilloscope (connected to the AC line through an isolation transformer for safety) to monitor the signal present across the secondary coil of the receiver transformer (or from the collector of transistor Q2 to ground), while you inject a signal for transmission using a sine-wave func-

(2a) (2b)

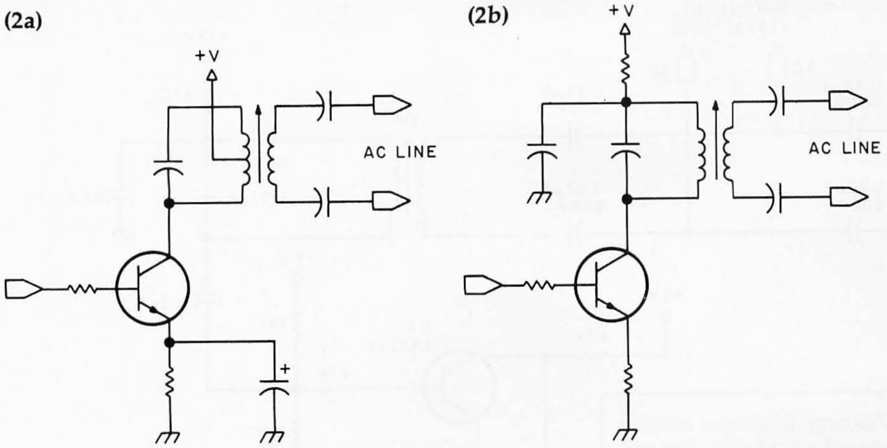


Figure 2: *Two possible schemes for coupling the modulator/driver portion of the carrier-current modem to the AC line. The circuit of figure 2b is the more stable.*

tion generator attached to the base of the driver transistor, Q1. Sweep the frequency between 50 kHz and 150 kHz until you detect the same frequency (at greater than 10 mV [millivolts]) at the receiver. Take care that you are receiving the fundamental frequency and not a harmonic. Don't be too surprised at the strange electrical noise you'll no doubt observe.

You can shift the detection band somewhat by adjusting the tuning slug in and out of the transformer windings or by changing the capacitor across the transformer secondary. The objective is to find the frequency band where the signal level at the receiver is highest. The band should be about 20 kHz wide; the frequency can go as high as 300 kHz (the upper frequency limit of the demodulator) if necessary.

In my case the best results were obtained between 80 kHz and 100 kHz, so I arbitrarily set two originate and answer frequency pairs within this band. One modem transmits on 90 and 95 kHz and receives on 80 and 85 kHz; conversely, the other modem transmits on 80 and 85 kHz and receives on 90 and 95 kHz. In a simple system, any originate and answer frequency pairs that work are acceptable because each frequency pair has its own tuned coupler. I recommend that the frequency separation between the mark and space tones be 5 kHz or less to facilitate easy demodulation. I only caution you not to set any frequency that is a multiple (or submultiple) of another one used in the system.

Remember that, in an analog FSK carrier-current communication system, success largely depends on your peaking the resonance of the coils and finding the proper transmission bands. I can't provide a parts list of components values that will be guaranteed to work because the behavior of parts in the list could be other than that predicted, due to performance and tolerance variations. The most important "component" in the coupler sections is your understanding the objective and knowing how to pursue it through testing and adjustment.

Fortunately, component selection in the FSK modulator and demodulator sections is much more straightforward and follows some basic formulas defined by the frequency and application. However, because it is possible that you might choose frequency pairs different from those in my design, I'll discuss the derivation of the component values rather than just the results.

Exar XR-2206 Modulator

First, let's consider the modulator. The XR-2206 is a function-generator integrated circuit, made by Exar Integrated Systems, which can produce sine, square, and triangular output waveforms at frequencies ranging from 0.01 Hz to 1 MHz. It is ideally suited for FSK applications because it can be set for two different time bases and digitally switched between them. A functional block diagram of the XR-2206 and typical FSK circuit is shown in figure 4.

The mark and space frequencies can be independently set by the choice of timing resistors R2 and R3 and the capacitor between pins 4 and 5. The FSK input signal is applied to pin 9. A high logic-input signal to pin 9 produces the frequency:

$$f_{high} = \frac{1}{R2 \times C}$$

and a low-level input signal produces the frequency:

$$f_{low} = \frac{1}{R3 \times C}$$

where R2 and R3 are in ohms and C is in farads.

R2 and R3 should be between 10 kilohms and 100 kilohms, and the capacitor should be polycarbonate, polystyrene, or Mylar for temperature stability. I chose to use a 0.001-μF capacitor, which produces the following resistor values for the frequency pairs I chose:

R2: 85 kHz, 11.76 kilohms
95 kHz, 10.53 kilohms

R3: 80 kHz, 12.50 kilohms
90 kHz, 11.11 kilohms

In the case of R2 and R3, you can use the nearest 1-percent-tolerance resistor or use a potentiometer in combination with the closest 5 percent fixed value.

You must also consider the settings of resistors R1 and R5, which adjust for minimum total harmonic distortion. In our case, where a few-tenths-percent distortion is irrelevant, pins 15 and 16 may be left open and R1 can be replaced by a fixed 200-ohm resistor. With R1 installed (same effect as closing switch S1), the output at pin 2 is a sine wave with an output impedance of 600 ohms and amplitude set by R4. The remaining components serve to stabilize operation and are the same for all frequencies.

XR-2211 Demodulator

The Exar XR-2211 is a phase-locked-loop (PLL) integrated circuit especially designed for data communication

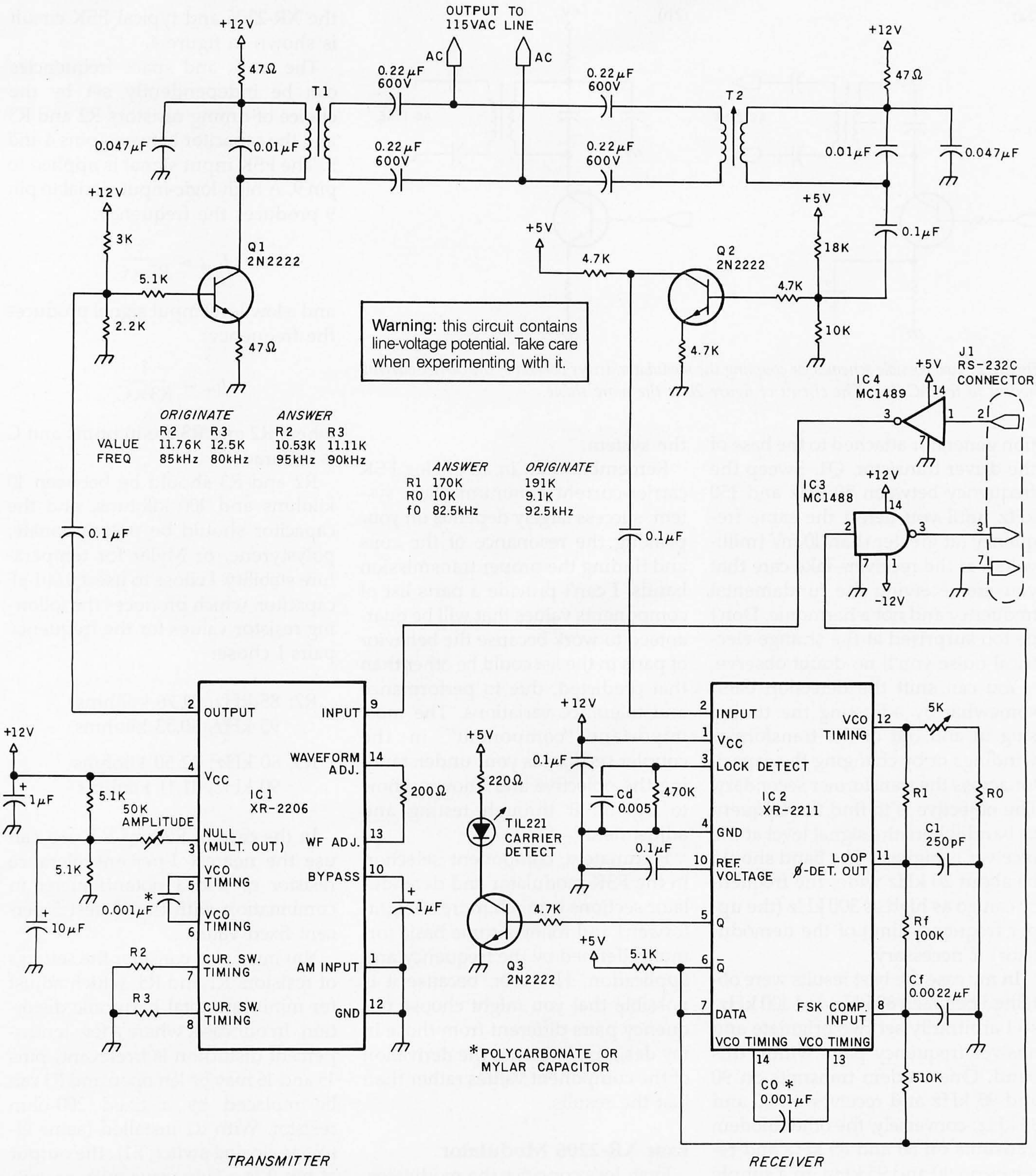
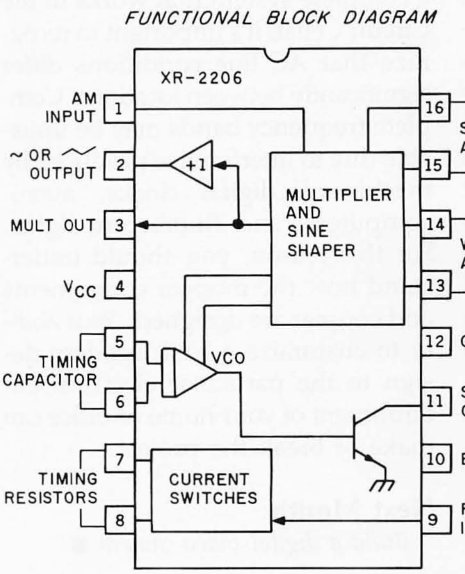


Figure 3: *Schematic diagram of a complete carrier-current modem. The originate-mode modem transmits mark signals at 90 kHz and space signals at 95 kHz; the answer modem transmits marks at 80 kHz and spaces at 85 kHz. This diagram shows the circuit for one end of the link; two such units are needed in the system with the proper component values differing between them. In one unit, the wiring of pins 2 and 3 of J1 should be reversed.*

and particularly suited for FSK applications. It operates over a frequency range of 0.01 Hz to 300 kHz and can accommodate analog input signals between 2 mV and 3 V. An XR-2211 functional block diagram and typical FSK demodulator circuit are shown in figure 5. Frequency-shift-keyed input signals fed into pin 2 of the XR-2211 must be capacitvely coupled through a 0.1-μF capacitor. The internal impedance is 20 kilohms, and the minimum recommended input signal is 10 mV.

The first order of business is to set

(4a)



(4b)

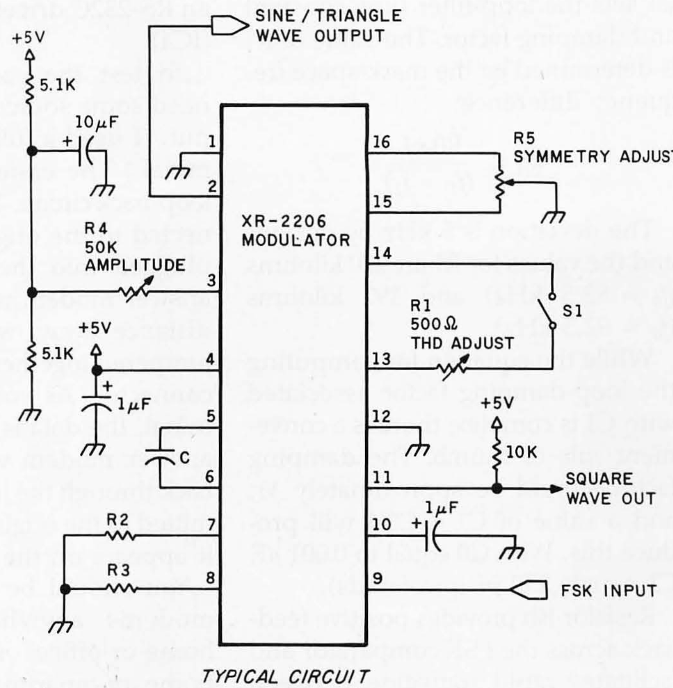
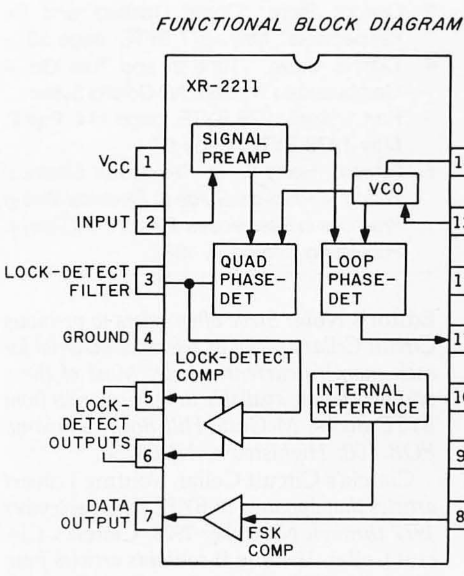


Figure 4: *A functional block diagram and pin-out specification of the XR-2206 (4a) and typical FSK circuit (4b).*

(5a)



(5b)

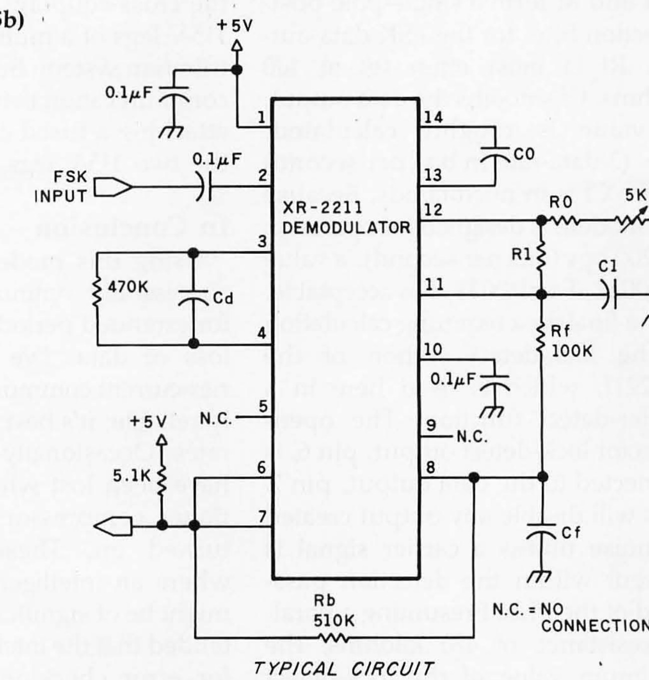


Figure 5: *An XR-2211 functional block diagram and pin-out specification (5a) and typical FSK demodulator circuit (5b).*

the center frequency of the demodulator passband at the center of the frequency band that we wish to detect. In my case, the passbands are defined by the tone pair at 80/85 kHz and the other pair at 90/95 kHz. The center frequencies for the two demodulators would then be 82.5 kHz and 92.5 kHz, respectively. The component values are computed as follows:

$$f_0 = \frac{1}{R0 \times C0}$$

where R0 is in ohms and C0 is in farads; f_0 is the center frequency.

Generally, R0 is in a range of 10 kilohms to 100 kilohms, but the choice is arbitrary. Often it is more convenient to choose a value for C0 and trim the value of R0 with an adjacent potentiometer. Using 0.001-μF value (Mylar, polycarbonate, or polystyrene) for C0, the computed R0 values are 12.12 kilohms (f_0 = 82.5 kHz) and 10.81 kilohms (f_0 = 92.5 kHz). With a 5-kilohm trim pot in series, more convenient resistors of 10 and 9.1 kilohms can be used instead.

R1 sets the *system bandwidth* and

C1 sets the loop-filter time constant and damping factor. The value of R1 is determined by the mark/space frequency difference:

$$R1 = \frac{R0 \times f_0}{(f_1 - f_2)}$$

The deviation is 5 kHz by design, and the values for R1 are 170 kilohms (f_0 = 82.5 kHz) and 191 kilohms (f_0 = 92.5 kHz).

While the equation for computing the loop-damping factor associated with C1 is complex, there is a convenient rule of thumb. The damping factor should be approximately ½, and a value of C1 = C0/4 will produce this. With C0 equal to 0.001 μF, C1 equals 250 pf (picofarads).

Resistor Rb provides positive feedback across the FSK comparator and facilitates rapid transition between output logic states. A value of 510 kilohms is used in most applications.

Cf and Rf form a single-pole post-detection filter for the FSK data output. Rf is most often set at 100 kilohms. Cf smooths the data output; its value is roughly calculated: Cf = (3/data rate in bits per second) where Cf is in microfarads. Because this modem is designed for operation at 1200 bps (bits per second), a value of 0.0022 μF or 0.0033 μF is acceptable.

The final area requiring calculation is the lock-detect section of the XR-2211, which is used here in a carrier-detect function. The open-collector lock-detect output, pin 6, is connected to the data output, pin 7. This will disable any output created by noise unless a carrier signal is present within the detection passband of the PLL. Presuming a parallel resistance of 470 kilohms, the minimum value of the lock-detect filter capacitor, Cd, is $16/(f_1 - f_2)/2$. In this case 0.005 μF is adequate.

Testing the Completed Unit

I built the complete Circuit Cellar carrier-current modem the way shown in figure 3, with component values for 80/85 kHz and 90/95 kHz tone pairs, but you may substitute other values as previously discussed. In addition to the three functional sections we have looked at, I have added a carrier-detect indicator and an RS-232C driver (IC3) and receiver (IC4).

To test the completed unit you need some source of serial data output. (I used a full-duplex video terminal.) The easiest test is a simple loop-back circuit. The terminal is connected to the originate modem and plugged into the power line. The answer modem is plugged in some distance away, with pins 2 and 3 jumpered together on J1, its RS-232C connector. As you type on the terminal, the data is transmitted to the answer modem where it is looped back through the jumper and retransmitted to the originate modem where it appears on the terminal's screen.

You should be able to place the modems anywhere within your home or office, or even an adjacent home or apartment. The ultimate range is limited by the power company's step-down transformer and the cross-coupling between the two 115-V legs of a multiphase 230-V distribution system. But you can arrange communication between the latter by attaching a fused capacitor between the two 115-V legs.

In Conclusion

Using this modem I was able to successfully communicate at 1200 bps for extended periods of time without loss of data. I've found FSK carrier-current communication to be fairly reliable; it's best at the lower data rates. Occasionally a few characters have been lost when my air-conditioner compressor or water pump turned on. These are occasions where an intelligent control system might be of significant help. I had intended that the intelligence necessary for error checking and redundant transmissions be part of this project, but as I explained, such a control system is much more involved than the modem itself. Given the excess computing power available in most personal computers, it would certainly be feasible in most cases for error-checking to be performed by applications software, perhaps using something like the well-known file-transfer protocol developed by Ward Christensen for use with his CP/M-based Modem-7 program.

Generally speaking, while I have detailed the hardware components of a complete system that works in the Circuit Cellar, it's important to recognize that AC line conditions differ significantly between locations. Complete frequency bands may be unusable due to interference produced by machinery, digital clocks, microcomputers, and fluorescent lights. For this reason, you should understand how the modem components and coupler are designed. Your ability to customize a basic modem design to the particular electrical environment of your home or office can make or break the project.

Next Month:

Build a digital video camera. ■

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Editor's Note: *Steve often refers to previous Circuit Cellar articles as reference material for each month's current article. Most of these past articles are available in reprint books from BYTE Books, McGraw-Hill Book Company, POB 400, Hightstown, NJ 08250.*

Ciarcia's Circuit Cellar, Volume I *covers articles that appeared in BYTE from September 1977 through November 1978.* Ciarcia's Circuit Cellar, Volume II *contains articles from December 1978 through June 1980.* Ciarcia's Circuit Cellar, Volume III *contains the articles that were published from July 1980 through December 1981.*

Steve Ciarcia (POB 582, Glastonbury, CT 06033) is an electronics engineer and computer consultant with experience in process control, digital design, nuclear instrumentation, product development, and marketing. In addition to writing for BYTE, he has published several books.

To receive a complete list of Ciarcia Circuit Cellar project kits available from the Micromint, circle 100 on the reader service inquiry card at the back of the magazine.

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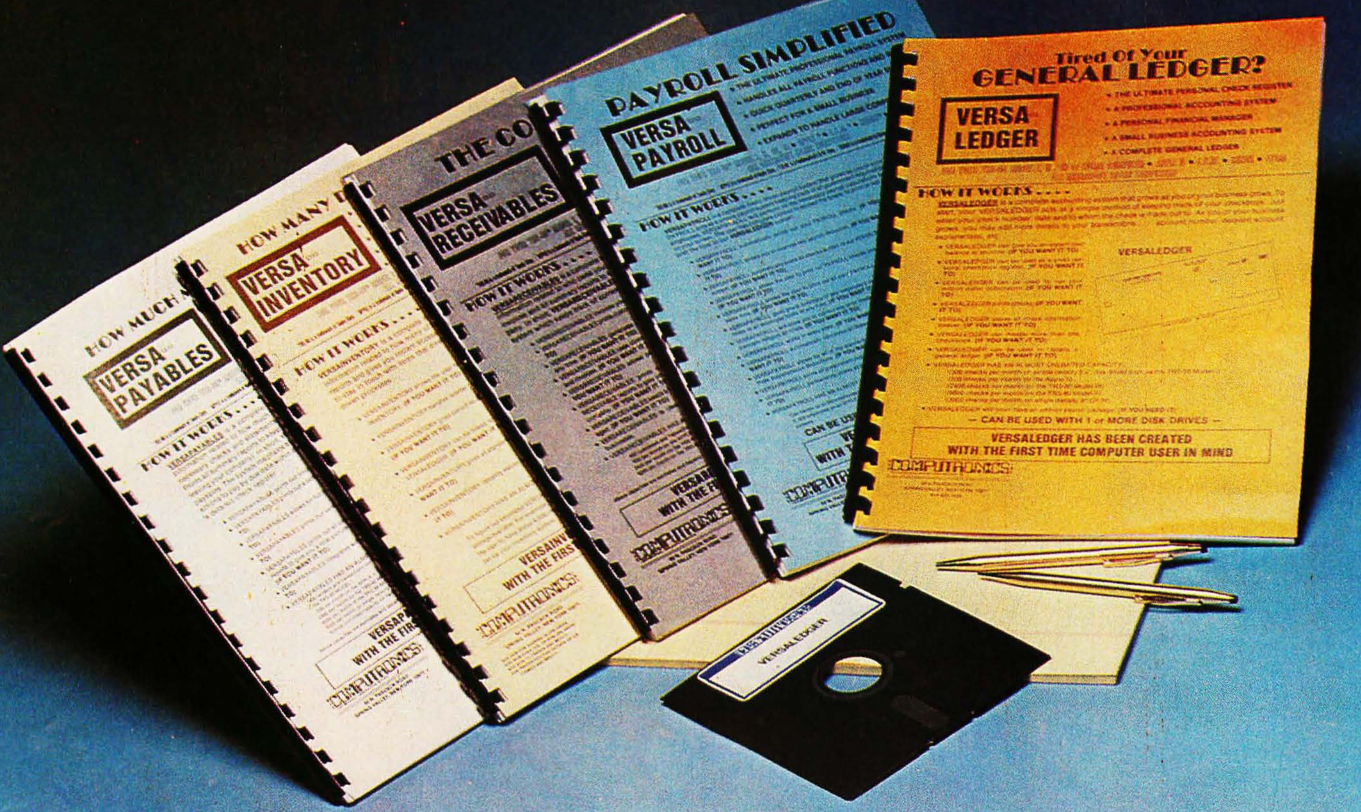

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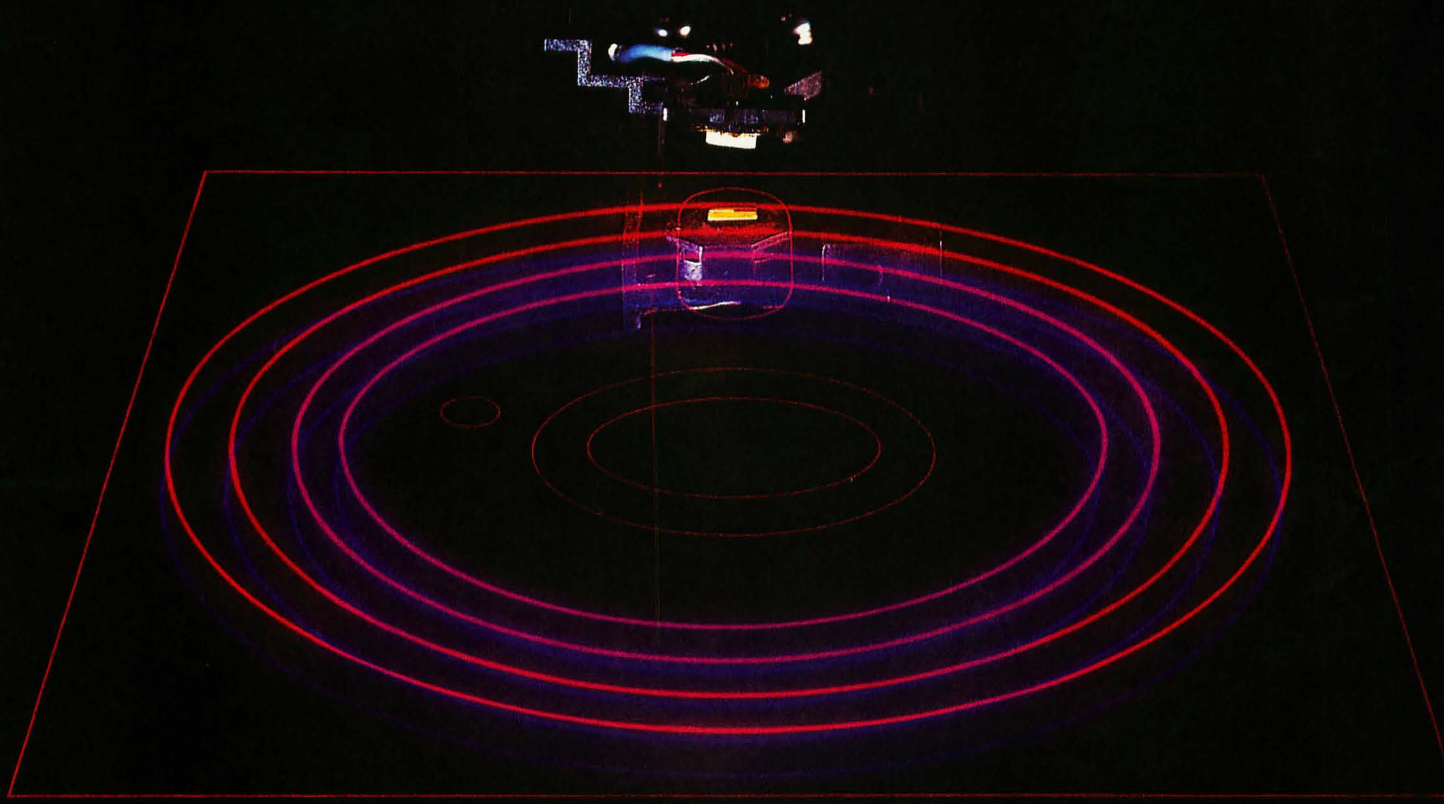

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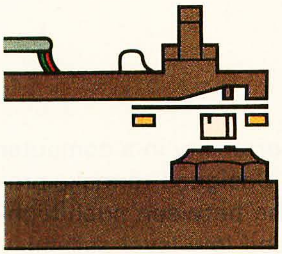

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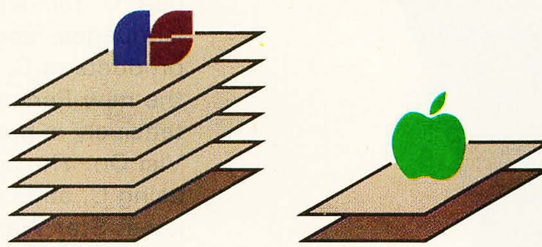

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THE C LANG

The C language provides a new standard for portability in a computer world characterized by a plethora of processors. Designed to make programs portable, fast, and compact, C fills a niche between such high-level languages as BASIC, COBOL, and Pascal and low-level assembly languages tied to particular processors. Perhaps most aptly described as a "medium-level" programming language, C is a powerful tool in the hands of professional programmers.

Most major microcomputer manufacturers and software developers use C for writing systems programs—operating systems, utilities, languages, and applications. Digital Research is writing all of its new products in C, including CP/M-68K for the 68000 microprocessor and the new Personal BASIC. Both Microsoft and Visicorp have used C extensively in products ranging from Multiplan and Xenix to Visiword and Visi On. The computer graphics sequences in *Star Trek II* were created using C, and Lucasfilm Ltd. used C for computer-aided animation in the latest Star Wars saga, *Return of the Jedi.*

Why is C so popular? The primary reason is that it allows programmers to easily transport programs from one computer or operating system to another while taking advantage of the specific features of the microprocessor in use. And C is at home with systems from 8-bit microcomputers to the Cray-1, the world's fastest computer. As a result, C has been called a "portable assembly language," but it also includes many of the advanced structured-programming features found in languages like Pascal.

Our theme articles in this issue take a close look at the C language. Stephen Johnson and Brian Kernighan of Bell Laboratories present an overview of C and compare it with other computer languages in "The C Language and Models for Systems Programming." James Joyce offers a guided tour of C's key features, along with programs that illustrate C programming concepts and style, in the first of a two-part series, "A C Language Primer."

C is a concise language that has a small kernel of 30 reserved words, and its input/output specifics are gathered into a library of standard functions. That means the language can be brought up easily on new microprocessors, resulting in dozens of versions of C. We sampled a few of these for the most popular operating systems.

Most applications programs are becoming large and complex in order

C

that new users perceive them as easy to use. Jason Linhart discusses how to choose a suitable computer language for "Managing Software Development with C."

Not surprisingly, the largest number of C languages, and some of the most advanced, are available for the highly regarded IBM Personal Computer. Most of the C compilers for the IBM PC are also available for the MS-DOS operating system, on which the IBM PC-DOS is based. These are reviewed by Ralph Phraner in "Nine C Compilers for the IBM Personal Computer."

The CP/M-86 operating system has a wealth of C compilers as well. Authors Jerry Houston, Jim Brodrick, and Les Kent take a look at the first of those available in "Comparing C Compilers for CP/M-86." Christopher Kern reviews "Five C Compilers for CP/M-80." C has been available for CP/M-80 for a while, and as a result a strong C users' group and several volumes of public-domain software exist.

No discussion of C is complete without mentioning the Unix operating system, which is written in C. Unix and its utilities comprise over 300,000 lines of C source code, certainly the most ambitious C project yet. Developed more than 10 years ago at Bell Laboratories, both Unix and C are now coming into widespread use. To round out our coverage of C, in this issue we begin "The Unix Tutorial," a series of articles on the Unix operating system. Part 1 is an overview of Unix and its features along with a short history of how C and Unix were developed. Together, C and Unix provide one of the most comfortable working environments for professional programmers. A text box by Walter Zintz describes Unix and C resources.

Both the C language and the Unix operating system are based on modularity and short, general-purpose routines, a subject Rebecca Thomas explores in "What Is a Software Tool?" "The Unix C Compiler in a CP/M Environment" by Matthew Halfant looks at some of the issues and ambiguities involved in moving C programs between these two popular operating systems.

An annotated bibliography of C on page 268 lists the books and articles on C that have been published in the past few years.

C is relatively young for a computer language, but it is appropriate that, in its 10th anniversary year, C is being recognized as the powerful language for professionals that it is.

—Bruce Roberts

UAGE

The C Language and Models for Systems Programming

A compromise between assemblers and high-level languages, C helps programmers avoid the idiosyncrasies of particular machines

by Stephen C. Johnson and Brian W. Kernighan

The C language was created at Bell Laboratories by Dennis Ritchie in 1972. One of its first uses was to rewrite the Unix operating system, previously written in PDP-11 assembly language. In its early years, C was used to write other critical systems programs as well: compilers, parser generators, document formatters, and editors, to name a few. At the time, using a high-level language for such applications was a radical departure from standard practice; everyone knew that these programs had to be written in assembly language "for efficiency." Yet in many cases the C code, although clearly less efficient in any given routine, produced programs that outperformed similar programs written in assembly language.

A key to understanding the philosophy behind C is the notion of a model for the problem to be solved. Rather than try to deal with all of reality in every line of code, programming languages, explicitly or implicitly, construct models of reality and present them to the programmer. In assembly language, for example, part of the language model is that the programmer need not be concerned with the actual memory location of the variables; they can be referred to by names like start or count. This simplification makes it far easier to program in assembly language than to write the binary bits that actually control the processor. The assembly-language model does, however, leave the allocation of registers and the choice of machine instructions to the user.

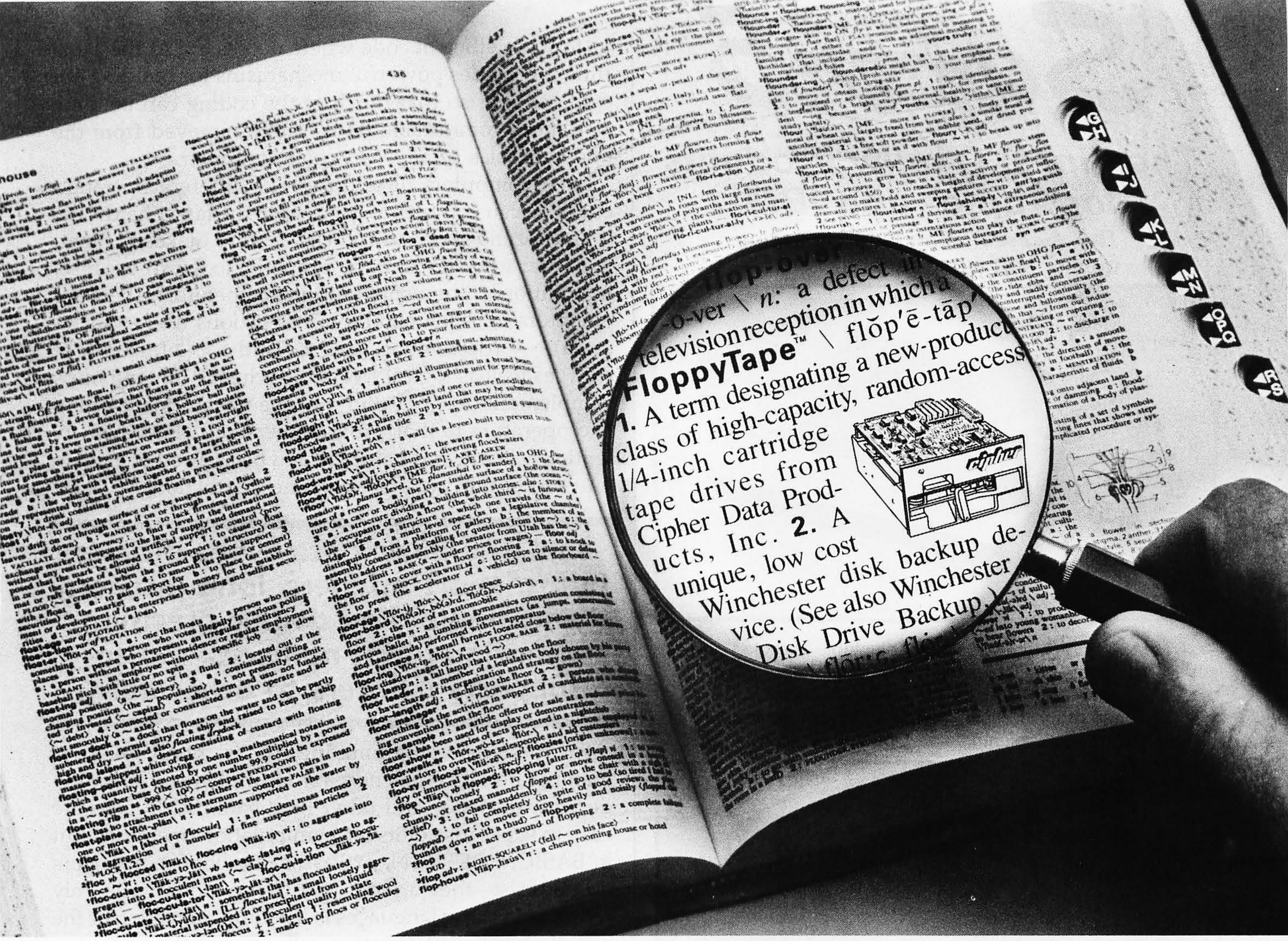
BASIC provides another model, similar to that of a very good programmable calculator. For many purposes, BASIC programmers do not have to worry about the details of where variables are stored, how arithmetic is done, or how to format output. As a result, BASIC is much easier to use than an assembly language.

The Smalltalk system supports a very different model. The Smalltalk programmer manipulates *objects* whose physical locations are invisible to the user, as are the details of the object's creation, manipulation, and internal structure. This model leads to a very different style of use; for example, rather than calling a routine to print an object, a Smalltalk user sends a message to the object telling it to print itself.

High-level models like the one supported by Smalltalk tend to be easy to use (provided that the model supports what we want to do) but are often less efficient than low-level ones. The hardware support for some of these models, especially on microcomputers, is not very good; we may sacrifice efficiency for ease of use. In systems code, efficiency is often very important, so the use of high-level models may be impractical. On the other hand, the low-level model presented by assembly language is not ideal either. In an assembly language, the details of the machine being programmed are implicit in every line: how many registers it has, how it uses its stack, how the I/O (input/output) is done. Not only is assembly code too firmly attached to a particular computer and system, it is also harder to write because the model supplied to us, with its registers and branches, is too far from the application we are trying to write.

The C Model

C offers a compromise. It makes available a basic model that is very close to the target machine, enabling



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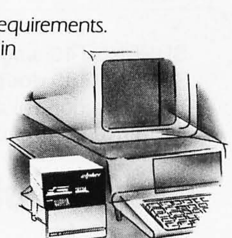

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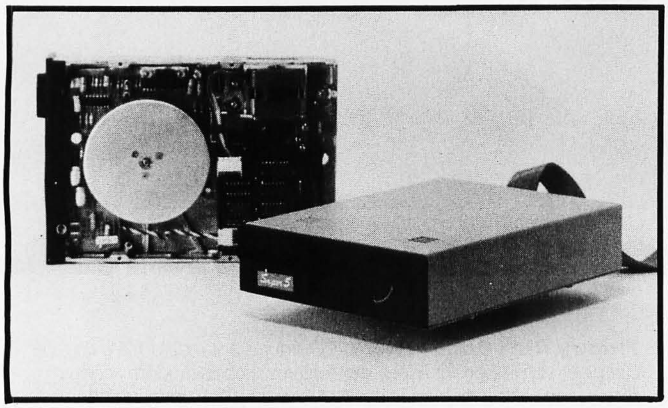

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us to write efficient code where necessary. At the same time it provides powerful mechanisms for building our own models, so that much of the coding can be done at a more comfortable level, safely removed from the idiosyncrasies of any particular computer.

Most computers have dozens of different operation codes; because C tries to get close to the target hardware, it has dozens of operators. This feature makes C slightly harder to read (or, more properly, to learn) because, in addition to the usual arithmetic operators, there are operators for such common instructions as ++ (increment), -- (decrement), and << and >> (left and right shift) as well as logical AND, OR, exclusive OR, and one's complement (&, |, , and ~). The reward for learning the operators is that programmers can state their intentions clearly and naturally and be assured of a direct translation into suitable machine instructions.

In C the basic data types include bytes, short integers, long integers, and single- and double-precision floating-point numbers. C also supports pointers to other data.

For systems programming, it is often vital to manipulate bits efficiently, for example, to control I/O devices, displays, and other hardware. Such tasks are easy in C because of its bit-manipulation operators. But in BASIC, FORTRAN, or Pascal, the bitwise operators do not exist—they are not part of the model. The only recourse in those languages is a painful emulation or the use of an efficient function call.

The model of data in C is also very rich. The basic data types include bytes, short integers (typically 16 bits), long integers (typically 32 bits), unsigned versions of these, and single- and double-precision floating-point numbers. C also supports the notion of pointers to other data; these pointers correspond to machine addresses. Because most hardware instructions deal directly with such addresses, the support of pointers encourages generation of extremely efficient code for critical program segments and the building and manipulation of very efficient data structures.

Pointer Operations

The model of pointers supported in C includes the standard operations of taking the address of an object (& object) and accessing the object pointed to by a pointer (*p). For example, suppose that x is an integer and p is a pointer to an integer. (There *is no such thing as just* "a pointer"; it is always a pointer to a particular data type.) Then

```
x = 3;          /* set x to 3 (what else?) */
p = &x;         /* set p to address of x */
```

The content of p is the address of x; the value pointed

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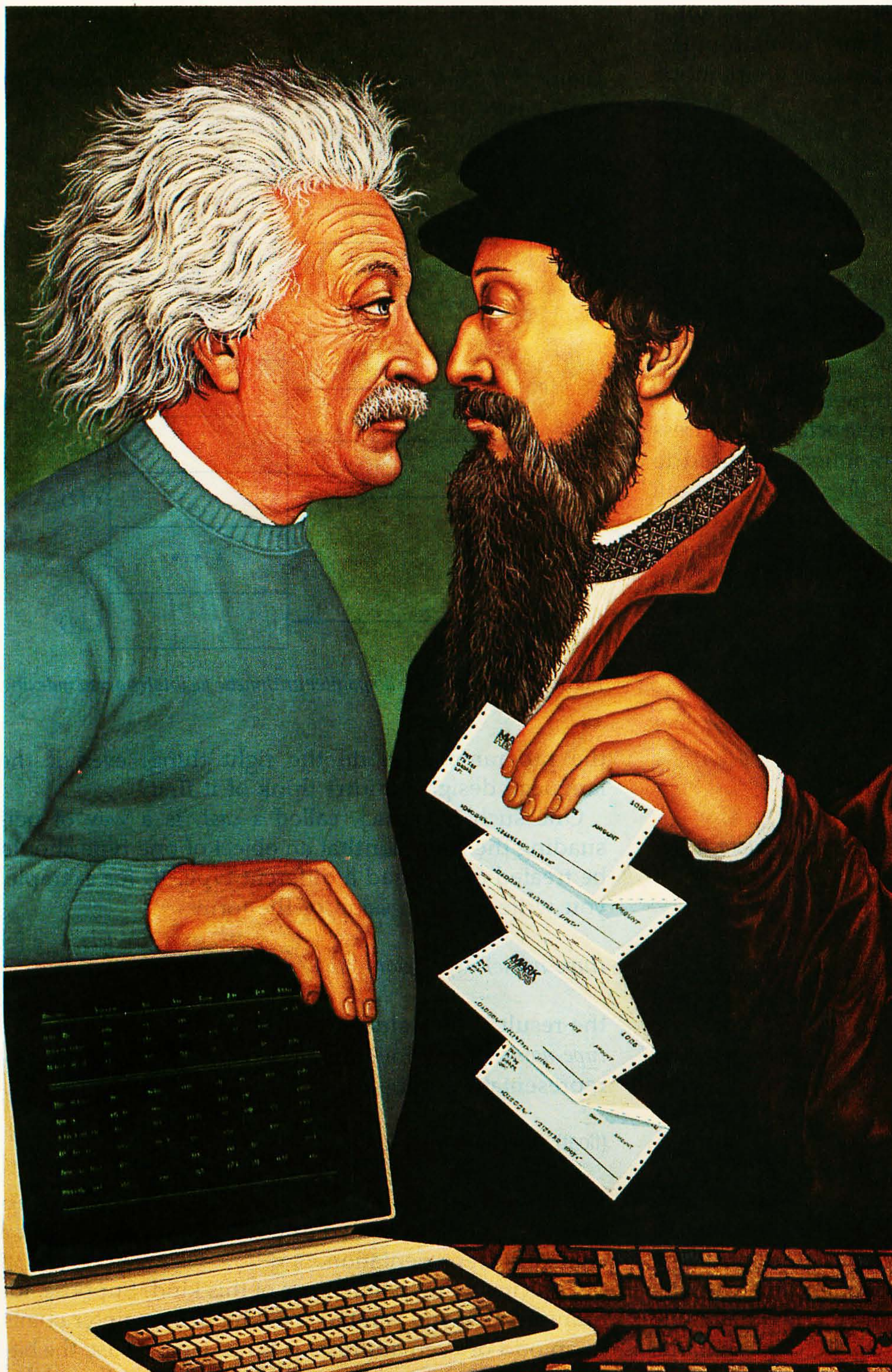

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to by p is written *p. Thus, in this case, *p is 3. Conversely, *p can be used to set the value of x:

```
*p = 4;            /* x is now 4 */
```

It is also possible to use the value of the pointer itself: if q is also a pointer to an integer, then the statement

```
q = p;             /* make q point to whatever p points to */
```

gives q the same value as p, so q also points to x. Figure 1 illustrates this operation.

Beyond this capability, which is more or less what Pascal provides, C includes the ability to manipulate pointers in ways that depend on what they are pointing to. For example, if we have a pointer to a byte, and increment it, it points to the next byte; if we have a pointer to a 16-bit integer and increment it, it points to the next integer (2 bytes away). Pointers are an excellent way to do array indexing, as shown in figure 2, where x is an array of integers.

In contrast to the pointer capabilities of C, FORTRAN and BASIC have a restricted model that does not include pointers. In Pascal, pointers are dynamic objects that can be set only by calling the storage allocation function new. Pascal does not allow pointer arithmetic.

Another use of pointers in C is to associate an address with a device. Most BASIC programmers are used to PEEK and POKE statements sprinkled liberally throughout their programs to access memory locations that control devices. In C, pointers achieve the same effect without the need to add a new pair of functions. In BASIC, you set a memory location by a sequence such as

```
100 V = 36828
...
800 POKE(V, 15)
```

In C, the same code might be written as

```
sound_vol = 36828;     /* sound generator volume address */
...
*sound_vol = 15;       /* set sound generator volume */
```

With the freedom implicit in C's use of pointers come certain risks. Much of C's growth over the last decade has been in ways of detecting erroneous uses of pointers without restricting the ability to write efficient code when necessary.

Casts

Operating systems have to deal with some very unusual objects and events: interrupts; memory maps; apparent locations in memory that really represent devices, hardware traps and faults; and I/O controllers. It is unlikely that even a low-level model can adequately support all of these notions or new ones that come along in the future. So a key idea in C is that the language model be flexible, with escape hatches to allow

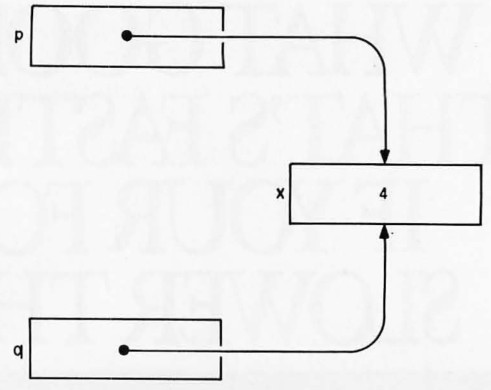

Figure 1: *If pointer* p *points to location* x, *then the statement* q=p *makes* q *point to* x *also.*

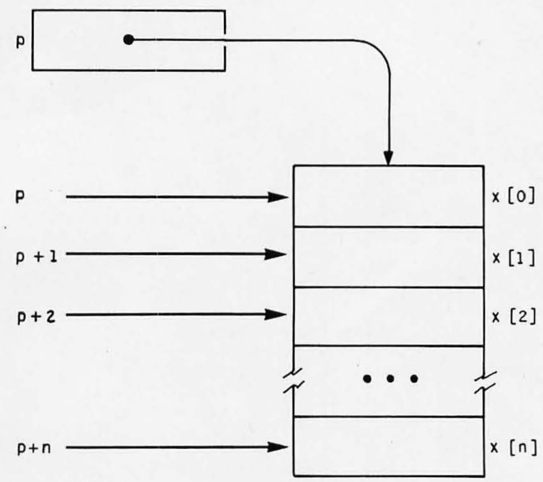

Figure 2: *The ability to do pointer arithmetic facilitates array indexing.*

the programmer to do the right thing, even if the language designer didn't think of it first.

One such construct, called a *cast*, is a way of persuading the compiler that an object of one type should be treated as if it had a different type. If, for example, you write an expression of the form

(type-name) expression

the result is the value of *expression* as an object of type *type-name*. For some combinations, this causes a new representation to be computed, as in

(float) *integer expression*

but sometimes it simply means that the bits in the expression are to be treated as a different type without a change in representation.

Casts involving pointers are of this kind. Suppose, for example, that you want to test whether a pointer points to an odd or even address. It is not legal to use the bitwise operators on pointers, but you can do the job by

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casting a pointer to an integer and then testing the low-order bit with a logical and operator:

```
if ((int)p & 1)
        { . . . pointer is odd }
else
        { . . . pointer is even }
```

The cast (int)p changes the interpretation of the pointer p without changing its value.

A very similar example is the mechanism used with the standard storage allocator. The C library function calloc is analogous to the Pascal new function; it returns a pointer to a block of storage. The pointer returned by calloc must be cast to the proper type:

```
pthing = (thing *) calloc(n, sizeof(thing));
```

This tells the compiler that the pointer returned by calloc may be safely regarded as a pointer to an object of the type thing.

Higher-Level Models

We need not be stuck with a machine-level model for long. C provides a number of ways by which we can extend the basic model to support data structures and operations important to our particular program. The two major ways to extend the model are by defining functions and making data structures, as a simple example illustrates. Suppose you are writing a video game and want to have a number of pictures moving around the screen. You could define a data structure that describes the objects using the struct mechanism of C; such a data structure might contain the *x* and *y* coordinates of the current picture, enough information to draw the picture on the screen, and other information of importance for the game (such as orientation, velocity, amount of fuel remaining, etc.). The declaration would look something like this:

```
struct picture {                /* picture for display */
            int x, y;           /* screen coordinates */
            float vel;          /* velocity */
            float fuel;         /* fuel remaining */
            disp_list *dl;      /* display list to print it */
};
```

You can then declare variables of this composite type and build functions that provide basic operations on it. Depending on the game, you might supply functions to create, change, and destroy pictures, move them from one place to another, and decide whether two pictures collide. At this point, you will have effectively raised the level of the model in which you program from bits and bytes to picture manipulation. You can concentrate on the rules of the program rather than the implementation. Once you're comfortable with this style of programming, the nearly nonexistent model-building facilities of BASIC, say, become nearly intolerable.

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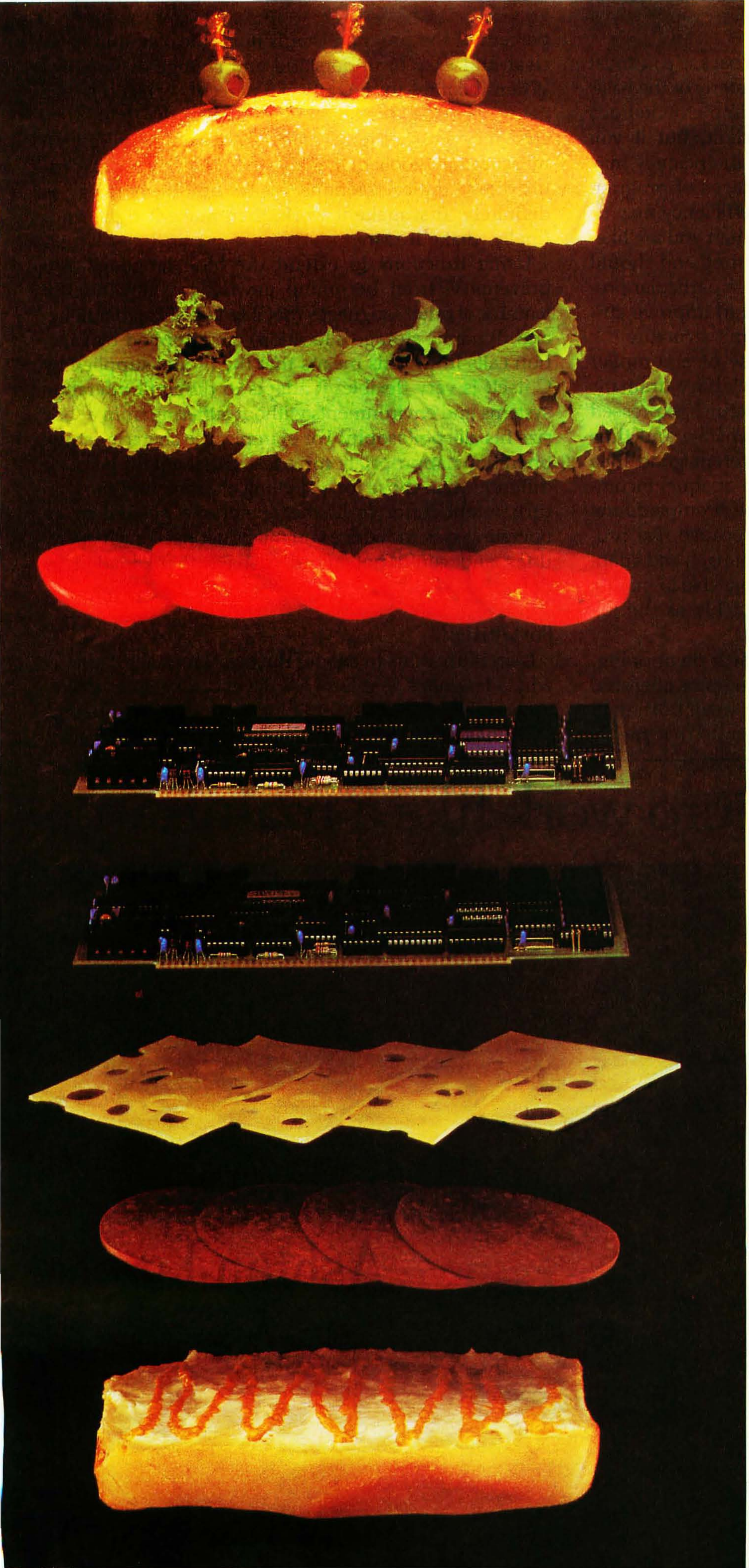

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Efficiency

Higher-level models have their drawbacks; you must pay for the function calls needed to do many of the basic operations on your pictures. Most C implementations try hard to make function calls efficient, but if you haven't skillfully chosen a model, the inefficiency may be painful. Especially in the earliest stages of program development, however, concern with efficiency may be misplaced. Why optimize a program when you are likely to decide tomorrow that it was all wrong and should be rewritten? The models are tailored to a particular program, so they may be readily adapted to improve efficiency without destroying the program's structure.

Although function calls and the use of a compiler language are somewhat inefficient, they have dramatic advantages. Algorithms and data structures expressed in a high-level language are comprehensible and thus more likely to be revised when a different good idea comes along. If they were written in an opaque, incomprehensible language, changes would be attempted rarely and successful even more rarely. Because real programs typically suffer a long series of changes and adaptations before a user ever sees them, being able to modify the algorithms and data structures quickly as the job changes leads to a better final product.

Another point about efficiency is worth mentioning. Many studies have shown that most programs spend 50 percent or more of their time in a very small portion (5 percent or so) of their code. This suggests that the 95 percent of the program that is noncritical should be as clear and easy to understand and change as possible. When it comes to the critical 5 percent, C lets the user get very close to the target machine in order to improve efficiency. Furthermore, many C environments contain measurement tools that enable the programmer to identify these critical sections easily. But the strategy is definitely: first make it work, then make it right, and, finally, make it fast.

Using functions to extend the base language also prevents C from becoming unwieldy. Many built-in features of other languages (notably I/O, string handling, and dynamic storage allocation) are supplied by function calls in C. This means that the model supplied by C itself is very flexible; it adapts to different operating systems and environments without suffering from a "one size fits all" philosophy. For example, the character-string operations appropriate for a text editor might be quite different than those for a spelling checker, and those in turn might differ from the operations needed in an operating system (where you might not need such operations and could not afford to have them loaded by default).

Portability

Using functions to extend the base language explains why a language that is so low level can be so portable. C compilers have been built for more than 40 different machines, from the Z80 to the Cray-1. The Unix system

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has been moved to over a dozen machines, with new entries coming in weekly. All this from a language that won't even commit itself to the number of bits in a byte!

C programs are portable to the extent that the model they support is portable. A portable I/O library provides simple formatting and file-manipulation facilities. The model is so simple that it can be supported on most operating systems. If your application uses that model of I/O and you use the portable I/O library, then you will have no problem with I/O. Similarly, C provides models of data that can be supported on many different machines; if your program uses only the features of the basic model, your program is portable. Unfortunately, data restrictions show up as you move from machine to machine. The most unpleasant are the differences that are now entrenched in the industry as to the ordering of bytes in a word. The PDP-11 and many descendants, for example, store the bytes from low to high, while the IBM 370, Motorola 68000, and many others store the bytes from high to low. The size of an integer may vary from 16 bits on most microcomputers to 36 bits or more on some of the bigger mainframes. Finally, some machines support 8-bit bytes, some 7, and some 9. If the model you use in your program depends on any of these features, your program will be portable only to those machines with the same feature.

Even when a program is not directly portable, however, the use of appropriate models lets much of the program be identical in different environments, with the differences isolated in subroutines or compiled conditionally. For example, the Unix file system has many properties that are independent of a particular machine: the naming conventions, hierarchy, protection mechanism, and allocation and deallocation. Machine-dependent features, such as the sizes of sectors on the disk and the number of files that may be defined, are hidden in a small number of machine-dependent functions and data descriptions. This means that the system is portable in the sense that it can be moved in much less time than it requires to rewrite it from scratch. The key to moving the system is to write the machine-dependent information that supports the underlying model. If the C code written does not fit the basic model (for example, type mismatches between a function definition and its uses), the code may work on one machine but fail on others.

No language is perfect, or even close, and C is no exception. Some of the early design decisions are at best open to serious debate. One is the treatment of floating-point quantities; the current C definition requires all intermediate floating-point expressions to be evaluated in double precision. This can lead to significant inefficiencies for floating-point applications. Another problem is the large number of operators that have side effects; this becomes even more serious when you observe that C makes no promises about evaluation order in an expression or, in particular, the order in which arguments to a function are evaluated. Consequently, some programs can fail when run on different machines, and it can be very hard to check for this problem mechanically. As a

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simple illustration, suppose that we have a function called print that prints the value of a variable n and the value returned by a function f. There is a natural tendency to believe that the statement

```
print(n, f( ));
```

will print the value of n, then the value returned by f. But if n happens to be a global variable that is changed by f, the results depend on the order in which the arguments of print are processed. This problem is certainly not limited to C, by the way—similar issues arise the same way in most languages.

The C Programmer

Another model implicit in a language environment is that of the programmer. Much of the C model relies on the programmer always being right, so the task of the language is to make it easy to say what is necessary. C encourages telling the truth about strange constructions (e.g., casts for pointer assignments) but does not prohibit them. The converse model, which is the basis of Pascal and Ada, is that the programmer is often wrong, so the language should make it hard to say anything incorrect. In Pascal (and presumably Ada) it is harder to say strange things and therefore perhaps harder to make mistakes.

By now it should be clear that C was intended as a language for professional programmers. Early C faced problems familiar to users of today's microcomputers (for years, the C compiler had to run in 12K bytes of program plus data), and many traits of the early years are still with us. The cryptic error messages in most compilers were relatively unimportant for professionals but tough on casual users. Also, C is definitely packaged as a compiler, not a programming environment, so input must typically be created with a text editor, placed in a file, and handed to the compiler. On some systems, this is rather painful, and it also makes it harder for the novice to get started. Finally, the large amount of freedom provided in the language means that you can make truly spectacular errors, far exceeding the relatively trivial difficulties you encounter misusing, say, BASIC. One or two such goofs while learning the language can lead a beginner to burn the manual. Despite its problems, however, C continues to be used and developed, a good sign that there is a place for a portable low-level language with powerful model-building facilities.■

Steve Johnson is head of computer systems research at Bell Laboratories (600 Mountain Ave., Murray Hill, NJ 07974) and designs languages for VLSI (very-large-scale integration) integrated-circuit design. He is the author of the Unix portable C Compiler and the YACC parser generator.

Brian Kernighan is head of computing structures research at Bell Laboratories and is interested in document preparation, programming languages, and programming methodology. He is the coauthor of The C Programming Language *and* Software Tools.

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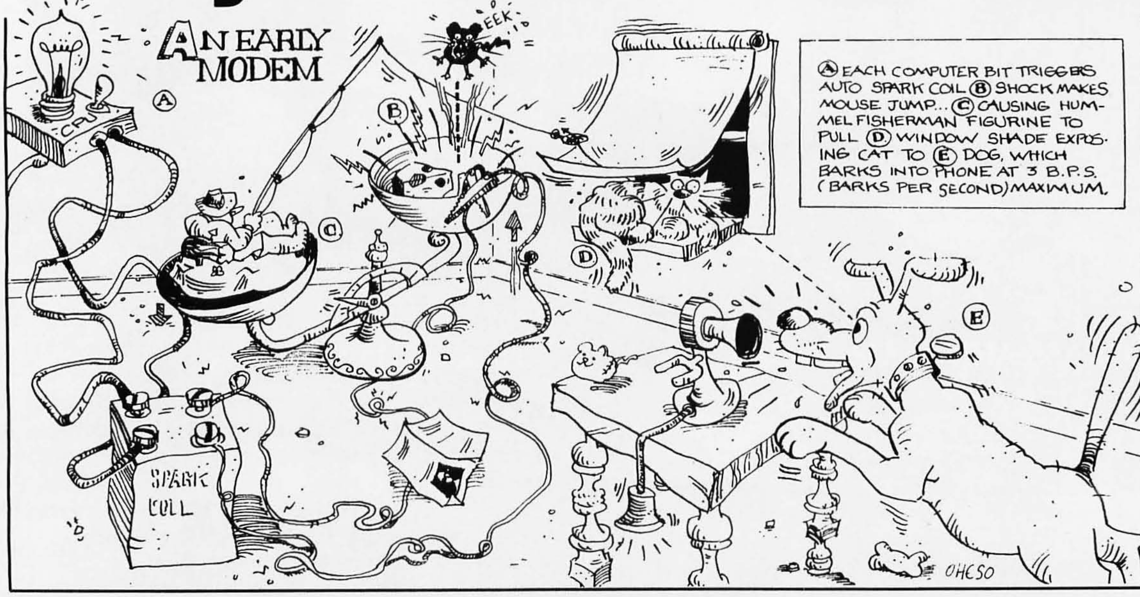

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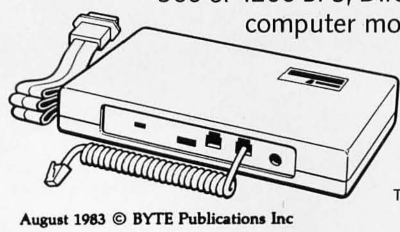

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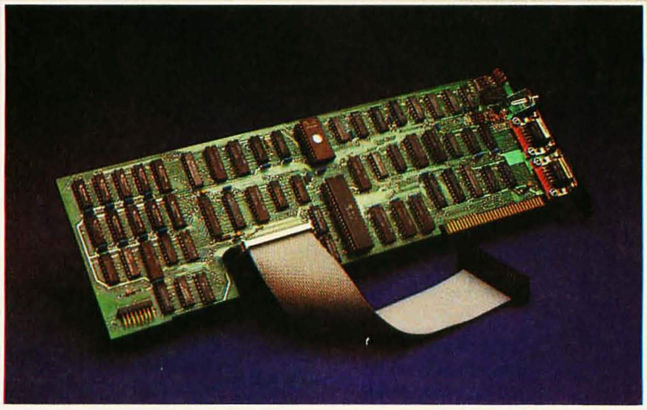

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A C Language Primer

Part 1: Constructs and Conventions in C

by James Joyce

Part 1 of this two-part article includes a brief overview of the C language and its history as well as examples of programs that demonstrate C's features. Because I have assumed that readers are familiar with a programming language, I have not defined such common programming concepts as variables, loops, functions, and arguments.

The examples that follow will help you to explore C's features. Each example is a small program that explores a single aspect of the language, placing the focus on the feature instead of on the program or its possible applications. The only drawback to this approach is that it sometimes sacrifices utility for exposition. For further explanation, I direct you to the definitive reference for useful C examples, The C Programming Language, *by Brian Kernighan and Dennis Ritchie.*

To reinforce what you learn, I recommend that you enter each program into a computer. After the program runs successfully, experiment with omitting or changing parts of it. Introducing deliberate errors will provide a controlled orientation to C's sometimes cryptic error messages and will be valuable experience for interpreting compiler diagnostics. As is the case with many programming languages, errors in C can have a cascading effect— when many errors are actually the result of one.

This article does not pretend to explain everything you will want to know about C. The idea is to get you started with key constructs and conventions in C that you will eventually encounter.

C was developed in Bell Laboratories at Murray Hill, New Jersey, in 1972. Created by Dennis Ritchie, it was based on the language B, Ken Thompson's adaptation of BCPL (basic combined programming language). Because the letters B and C are sequential in both the alphabet and in BCPL, some contend the successor to C will be D, and others say it will be P. As with ALGOL 68 and PL/I, many insist that C is *the* programming language and that it will last forever.

Unix and C have been intimately associated from C's beginning. Unix was originally written in assembly language, and transporting it to other hardware was a growing problem as new utilities and functions were added. With C available, Thompson and Ritchie rewrote Unix, leaving only a few very low-level routines in assembly language. Transporting Unix to another computer is mainly a matter of writing a C compiler for the target computer. Most of the several hundred C programs that make up Unix compile without a change in code on the new hardware, a feature that has helped make Unix and C so popular today.

Because C appears to be so portable, it is tempting to talk about "standard" C. Such a standard exists implicitly in the Unix program `lint`, which parses C programs looking for machine-dependent code. Though quite intelligent for a program, `lint` can be fooled.

A partner program in C standardization is `cb`, the C beautifier program, which reformats C code according to the program's structure. Thus a programming team can run its programs through `cb` to gain an overall uniformity of code format. Uniformity reduces the effort needed to get to know another team member's code, in turn making maintenance easier. The C beautifier can also be used as a debugging aid because comparing the reformatted version to the original may reveal misplaced or missing code.

Good style in C is important because C programs can be very hard to read. For example, compound statements

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that in Pascal are grouped by the keywords begin and end are grouped by the easy-to-miss { (leftbrace) and } (rightbrace) in C. Add to this the fact that C is free format (*without* line numbers), and the ill-considered placement of a brace can easily introduce a bug.

Another feature of C that can cause difficulty is that expression values can be changed in the middle of a logical test. The C instruction

```
if ( (byte = getchar( )) == 'X' ) count++;
```

causes the function getchar( ) to read a character, which is assigned to the variable byte and tested by == for equality to X, all within the conditional test of an if statement. This feature makes for compact code and can confuse the unwary.

C Program Structure

This is the smallest possible C program:

```
/*--- small.c   The smallest C program ---*/

main( )     /* a comment */
{
}
```

Comments in C are, as in all languages, optional but highly desirable. C comments are enclosed PL/I-style within the comment delimiters /* and */. A routine called main is required for each and every C program. The pair of braces in the subsequent lines are also required, and any executable code for main must appear inside them. Although the example is simple—there is no executable code, so the program does nothing—I encourage you to enter and run it.

To compile this example under Unix the command is

```
$cc small.c
$
```

C programs under Unix must be in a file whose name ends in .c , or else they will not compile properly. If the compilation is successful, there will be no messages from the compiler: the compile will end, and control will return to the shell (Unix's command interpreter), which uses the $ (dollar sign) to prompt for another command.

The ready-to-run program, which is named a.out, will be in your current directory. If the C compiler had detected errors, the errors alone would be printed, along with an indication of the line number at which the error had become obvious. You may need to examine other lines in the vicinity of the reported error to find the real culprit.

This "silent treatment" can be disconcerting if you're *new to C. But* as your confidence in writing C programs builds, you will grow to prefer its brevity. To learn what messages C gives when main, the parentheses, or the braces are missing, try running the program without them. This is good practice in reading diagnostics.

The cc command causes the compiled code to become an executable file named a.out. To run the program, simply type a.out. When the program has finished running, control is returned to the shell, which again prompts with a $. You see no output because small.c does nothing.

The entire program could have been written as one line, as shown here:

```
/*--- small2.c   The smallest C program, on one line ---*/

main( ) { }
```

The format of the first version is the style Kernighan and Ritchie recommend.

Functional Structure of C Programs

C programs are made up of functions, minimally the function main. Our first program can be thought of as a do-nothing function: there are no arguments given to the function, and no processing is done. Good programming style in C encourages you to structure a big program as a number of small functions. The good C programmer will break large programs into smaller ones and write a function for each. If each function can stand alone, the programmer eventually develops a "toolbox" of useful programs that can be combined in different ways to solve problems. This is a very important and powerful concept.

In the example that follows, main calls a function, doit, that doesn't do anything. This is a bare-bones example of a main program calling another function.

```
/*--- smallsub.c   Smallest C program with a subprogram ---*/

main( )
{
      doit( );
}

/*--- doit doesn't do anything ---*/

doit( )
{
}
```

The call to doit is given in main within the braces because functions are executable—even if they don't do anything but return control to the main function, as they do here.

A function is invoked by stating its name; arguments to be passed to the function are placed *within* parentheses after the name. The semicolon after the call to doit is C's statement terminator (as found in PL/I) rather than simply a statement separator (as in Pascal or other ALGOL-like languages). In other words, a semicolon must appear at the end of every legal statement in C.

After the code for main comes the definition of doit. The definition is like that of main, further emphasizing that

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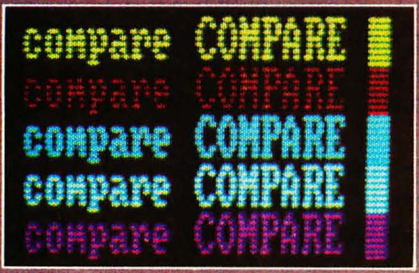

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C programs are made up of one or more functions. Function definitions may not be nested in C. That is, the definition of doit cannot be inside main. Once you have this program running successfully, try defining doit inside main's braces to view the message C gives.

Functions can be defined in any order, although main is typically the first function in a program. Try moving the definition of doit in front of main and compile the result to verify that functions can be defined in any order.

Printing a Message

The library function printf prints output on the standard output device, your terminal, unless redirected to another destination:

```
/*--- hello.c   Greet the world, introduce output in C ---*/

main( )
{
        printf(“Hello, world! \n”);
}
```

The message printed by this example is, of course,

"Hello, world!"

It is coded as a character string within parentheses in the printf statement. The printf statement is simply a function call. Notice that the string between the " (double quotes) ends with the two characters \n (backslash-n). This combination is C notation for a *newline* character, which on a computer's video terminal (or printer) will position the cursor (or print head) at the beginning of the next line.

In C, as almost everywhere in Unix, the \ (backslash) is the *escape character*, signaling that the character that follows is to be treated differently than it would be without the \. Other common combinations include \b for backspace, \f for form feed, \r for carriage return (to the beginning of the current line), \t for tab, \" for double quotes (rather than simply ", which would signal the end of the character string), and \\ to indicate the backslash.

All arguments of a function must be on the same line in C. Because printf is a function, the entire string within printf must be on the same line. If you have a particularly long character string to print, it can be broken up into several segments, each printed using a printf:

```
/*--- stream.c   Print “Hello, world” as stream output ---*/

main( )
{
        printf(“ \t”);
        printf(“Hello”);
        printf(“ , ”);
        printf(“ ”);
        printf(“world”);
        printf(“!”);
        printf(“ \n”);
}
```

Because only the last line contains a notation for a newline character, the printf statements print one after another on the same line. The output is a stream of characters, one after the other up to and including the newline.

Variables, Assignment, and Output

Variables in C may be any length, though only the first 8 characters matter (external variables and function names may be restricted to fewer characters, depending upon the machine being used). Variables must be declared explicitly:

```
/*--- var.c   Introduce printf to print a variable ---*/

main( )
{
        int age;

        age = 40;
        printf(“This year Sam is %d years old. \n”, age);
}
```

Although int is short for integer, you cannot use the term "integer" to declare a variable. The = (equal sign) in the statement following the declaration is used for the assignment of values to variables.

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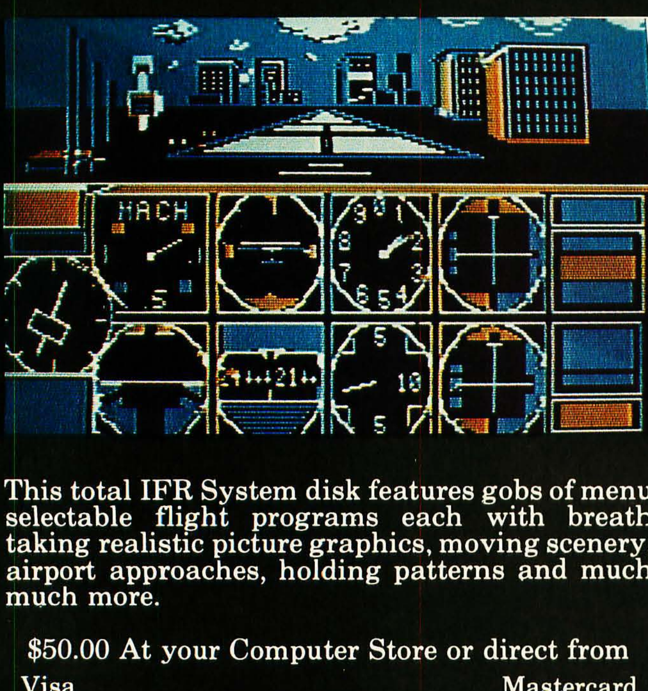

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Notice that the printf statement is slightly different and has two parts to it; a comma separates the character string, enclosed in double quotes, from the variable name age. The character string also has something new in it, %d , telling printf that a decimal integer is to replace the %d during output. The %d corresponds to the variable age; the printf function will allocate enough space in the character string for the width of the value that replaces %d. The value of age will be inserted into the character string to produce the following message:

```
This year Sam is 40 years old.
```

The character string is, then, an output control string for formatted output, providing guidance to the printf function.

Sometimes C programmers forget to declare a variable. You can discover C's message about that by deleting the int declaration, then recompiling the program. You can get the program to work again by deleting the assignment statement and substituting the constant 40 for age in the printf statement.

There are, of course, other variable types in addition to int, and you will meet them in later examples. C has several powerful control structures you will want to learn first, with other variable types introduced in appropriate circumstances.

Looping with while and Incrementing

We can use essentially the same program to introduce an aspect of looping while incrementing:

```
/*--- while.c   The while construct ---*/

main()
{
      int count;

      count = 1;
      while (count <= 4) {                        /* A */
           printf("%d \n", count * 10);            /* B */
           count = count + 1;                      /* C */
      }                                            /* D */
}
```

The statement with the comment /* A */ sets the condition, given in parentheses, that count be less than or equal to 4 for execution of the loop to continue. The loop includes the two statements within braces, beginning with the end of line A and ending with line D. The braces enclose a *compound statement* in C (i.e., one or more statements treated as if they were a single statement). That the brace in A is on the same line as the while is the preferred style in C.

The two statements in the loop print the desired number and increment the variable count. What's new here is that, in line B, we demonstrate that the variable in printf can be an expression—in this instance, count * 10 (the asterisk means multiplication). The expression in

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line C, count = count + 1, is not used much in C because there is a much shorter notation that we will examine in the next example.

Line D contains the brace that ends the while loop. It is lined up under the w of while as a matter of style. As an experiment, you can remove the statement that sets count to 1 to learn how C treats an undefined variable. (Some undefined variables are given an initial value by the C compiler so that they don't have garbage in them. More on this can be found in section 1.10 of Kernighan and Ritchie's book.) In this instance, the value of count is arbitrary, and you may have a runaway loop (on most Unix systems, this can be stopped by pressing the Break key or the Rubout key).

In the example that follows, the term count++; replaces count = count + 1; .

```
/*--- while2.c   The increment-by-one operator ---*/

main( )
{
        int count;

        count = 1;
        while (count <= 4) {
              printf("%d \n", count * 10);
              count++;
        }
}
```

This illustrates a powerful legal C construct, the increment operator, which is unusual in high-level languages. The ++ assures the C compiler that you're telling it you want to increment count and that you have not mistyped the statement. The ++ is an operator that means "increment by one," and under some circumstances it is faster than using count = count + 1; (it is certainly easier to type). Although it is not required, putting the increment-by-one operator next to the variable it affects, without intervening spaces, helps those who must read the code later.

Here's a further example of how the increment operator may be used in C:

```
/*--- while3.c   Increment-by-one in expressions ---*/

main( )
{
        int count;

        count = 1;
        while (count <= 4) {
              printf("%d \n", count++ * 10);           /* E */
        }
}
```

In line E, the variable count has been rewritten count++ so that the increment-by-one operation is done within the printf statement. Some feel this and similar practices make C hard to read, and for the uninitiated that can be true. You should be aware of this use of ++ , if only so that you can read other C programs. With practice you may even grow to feel this use is quite natural.

It is instructive to change count++ to ++count in the above example and then run it. The ++ operator may be used as both a suffix and a prefix, to affect the contents of a variable before the expression is evaluated or after. When ++ is used as a suffix, count is initially 1, its value is printed, count is incremented, and the loop begins again. When ++ is a prefix, count is initially 1, but count is incremented before its value is printed.

There is a corresponding "decrement by one" operator, --, which follows the same rules. If you experiment with the increment and decrement operators, keep in mind that you may want to change <= (less than or equal) to >= (greater than or equal) to prevent the program from going into an infinite loop. Try changing count to count++ in the while instruction, leaving simply count in the printf statement.

Looping with for

C's for statement has three parts within its parentheses:

```
/*--- for.c   The for construct ---*/

main( )
{
        int count;

        for (count = 1; count <= 4; count++)           /* A */
              printf("%d \n", count);                  /* B */
}
```

The first part initializes the for. The second indicates the condition allowing the loop to continue. The last part indicates what is to be done at the "bottom" of the loop (in this example, count will be incremented *after* printf prints).

The body of the for loop is given in line B. You might want to add a printf after the for loop to see that the loop-controlling variable, count, retains its value outside the loop. This contrasts with for loops in Pascal and do loops in FORTRAN, in which the loop-controlling variable is technically "undefined" upon exit from the loop.

The printf can also be included in the third part of the for loop:

```
/*--- for2.c   The for loop with null statement body ---*/

main( )
{
        int count;

        for (count = 1; count <= 4; printf("%d \n", count++))
        ;                                                  /* C */
}
```

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The lone semicolon in line C is still required by the syntax of the for loop, and it ends the null (or empty) statement that makes up the body of the loop. There is nothing in the loop; all action takes place in the parentheses after the keyword for. This practice, which occurs often in C, can result in fast code. The danger in this practice is that someone reading the code may later miss the null statement and mistakenly think the next construct is included in the for loop. To help avoid such misreading, the semicolon in line C is lined up under the f in for.

getchar and putchar

Now that you know several basic control structures, you're ready to be introduced to the library functions getchar and putchar. As functions, they are not part of C proper but are basic extensions necessary for writing most programs. The function getchar receives one character from *standard input* (the terminal's keyboard), and putchar sends one character to *standard output* (the terminal's video display).

The following simple program using getchar and putchar will copy one character at a time from input to output until it finds an end-of-file indicator:

```
/*--- copy.c   Copy input to output ---*/

main( )
{

        int byte;                                   /* A */

        while ( (byte = getchar( )) != -1)          /* B */
              putchar(byte);                        /* C */
}
```

The end-of-file indicator from a terminal is a Control-D with Unix, which getchar signals by returning the integer −1; thus, to get out of this program, you need only type a Control-D at the keyboard. CP/M uses Control-Z for an end-of-file marker.

Line A declares byte as an integer, which at first seems strange because, as we said, the program copies characters; but the getchar function returns other values besides characters (among them the integer −1, which doesn't fall within the range of the char type). There is at least one version of C in which byte can be declared char and the end-of-file test in B will still work. Try changing int in A to char and rerun the program to see how your version of C behaves. If you run the char version of this program through lint, it will indicate that the "comparison" in line B is "nonportable."

So long as the condition in line B is true, the while loop will continue. It is a complex-looking expression, but you can break it into its parts readily if you work from the inside parentheses out: getchar is called and the value it returns is assigned to byte; the value of byte is then tested against −1, and so long as they are not equal (the != means inequality), line C is executed and the loop continues. The call to putchar has byte as its argument, with the result that the contents of byte are sent to the standard output.

The C compiler employs a *preprocessor* that can be quite useful in making programs readable:

```
/*--- copy2.c   Use preprocessor variable for EOF ---*/

#define EOF -1                                      /* D */

main( )
{
        int byte;

        while ( (byte = getchar( )) != EOF)         /* E */
              putchar(byte);
}
```

The # in line D is an indication that define is an instruction to the preprocessor. (Several other preprocessor instructions are given by Kernighan and Ritchie.) The action of the preprocessor can be likened to the expansion of macroinstructions in an assembler—it is not a separate program from the C compiler. Before the lines of the program are compiled, the #define instructs the preprocessor to replace every occurrence of EOF with the constant −1.

With the substitution made, line E in this program will mean the same thing to the C compiler as line B does in the previous example, and using the preprocessor makes the line more readable. This enables us to give symbolic names to special numbers (such as −1, when it signals end-of-file) or array boundaries in declarations or loops (as we shall see next month). The preprocessor will then replace the symbols in the program with the proper values before compilation. This approach improves both readability and maintenance.

We now know of two functions used for output: printf and putchar. Here is a quick illustration of how printf can be used in place of putchar in the previous example:

```
/*--- copy3.c   Show printf equivalent of putchar ---*/

#define EOF -1

main( )
{
        int byte;

        while ( (byte = getchar( )) != EOF)
              printf("%c", byte);                   /* F */
}
```

The format specification %c tells printf that a single character of data is to be printed. Changing %c to %d will not produce a character, but rather a numeric (integer) interpretation of the value in byte. Normally we want to distinguish between character data and its possible in-

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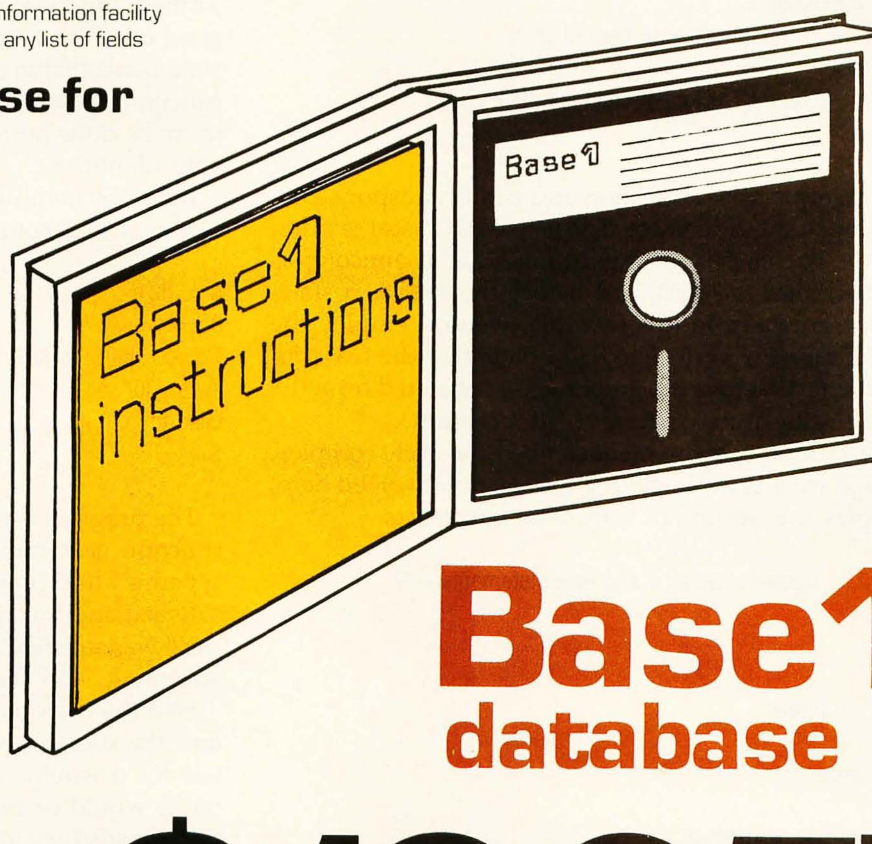

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terpretation as numeric data because dwelling on the interrelationship of char and int brings us too close to matters that are machine dependent.

if and else

C's if statement looks like if statements in many programming languages.

```
/*--- if.c  Illustrate the if and else statements ---*/

main( )
{
        int answer;

        printf(" \tDo you like C so far? \n");                    /* A */
        printf(" \tType y for yes, or n for no: ");

        answer = getchar( );
        if (answer == 'y')
                printf(" \tGlad to hear it! \n");
        else
                printf(" \tHope it changes. \n");
}
```

This example asks a question and prints a response depending upon the answer. Those used to Pascal or other ALGOL-like languages should note that a semicolon is required after the printf, just before the else, as a statement terminator. In this example, we also employ the logical operator == (is equal to). Note that the two printf statements that give the greeting are separated from the get-the-work-done portion of the program.

The logic of an if statement can become quite complex. Though we will avoid getting too deeply involved here, C allows the nesting of if and else constructs:

```
/*--- if2.c  Illustrate nested if and else statements ---*/

main( )
{
        int answer;

        greet( );

        answer = getchar( );
        if (answer == 'y')
            printf(" \tGlad to hear it!\n");
        else if (answer == 'n')                                   /* B */
            printf(" \tSorry to hear that. Hope it changes. \ n");
        else
             printf ("I don't understand %c.", answer);
}

greet( )  /*--- greet the user ---*/

{
        printf(" \tDo you like C so far? \n");
        printf(" \tType y for yes, or n for no:");
}
```

Line B shows that if the answer character is not y, the program is to check whether the character was an n. If that test fails as well, an error message is printed.

In C, an else refers to the most recent if that does not already have a closer else. Kernighan and Ritchie think all if and else statements should be lined up under each other, no matter what the depth of nesting, to prevent the code from drifting off the right-hand side of the screen or page. But the risk of associating the wrong else with an if seems too great without indenting, and the consequences too hard to detect, so I propose using the approach illustrated. (This is an instance in which the cb program perhaps should indicate its perception of the program structure; instead, it dutifully formats according to Kernighan and Ritchie's suggestion.)

Good programming style encourages you to structure programs as a number of small functions. While this is not a big program and could quite easily be written as a single function, the idea of structuring code is still a good one. There is no need to clutter main with the printf statements that greet the user. They belong in their own function. If someone wants to modify the greeting later, it can be done more easily with the printf statements suitably identified.

It may be helpful to see what this example would look like as it was compiled and run under Unix:

```
$ cc if2.c
$ a.out
Do you like C so far?
Type y for yes, or n for no: y
Glad to hear it!
$
```

The program typed the question through a call to the function greet and then waited for a reply. The user typed a y and pressed the Return key. The first if was satisfied and the appropriate message printed. Because the if was satisfied, there is no need to consider the else statement, and the program ends.

Had the response been n, the first if would have failed and the else statement would have taken effect. The if test for n would be satisfied and the message of sympathy would be printed. Again, satisfying the if condition means the subsequent else is skipped and the program ends. If the response had been anything other than y or n (even uppercase Y or N), the third else statement would have taken effect.

Here is a program that plays a simple guessing game with its user, testing for the correct response by use of the if statement. If the user types the letter e, the program points to it and announces, "You guessed it!"

```
/*--- if3.c  Illustrate the if and break statements ---*/

#define EOF -1

main( )
{
```


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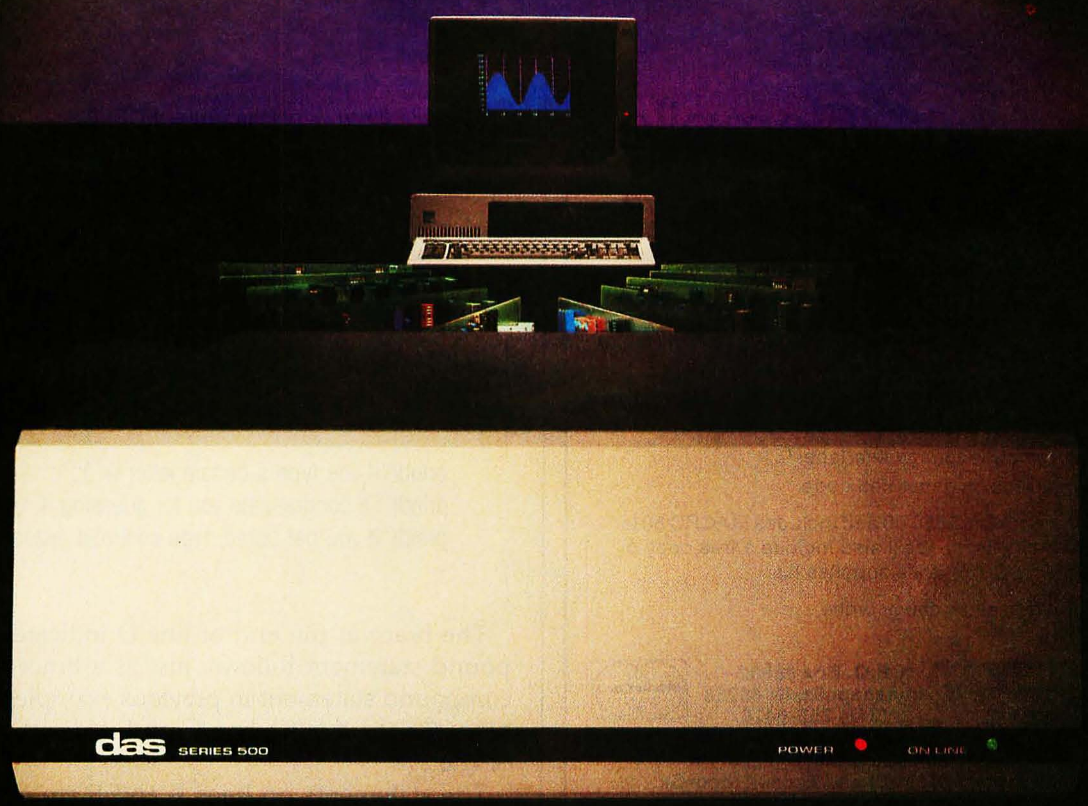

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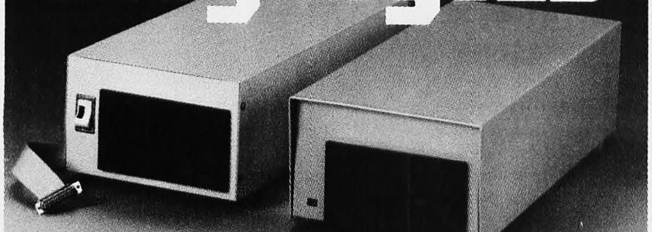

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```
    int byte;

    greet( );

    while ((byte = getchar( )) != EOF) {
        if (byte == 'e') {                              /* D */
            printf(" ^—You guessed it! \n");           /* E */
            break;                                      /* F */
        }                                               /* G */
        putchar (byte);
    }                                                   /* H */
}

greet( )  /*--- Print a greeting to the user ---*/
{
    printf("If you type a certain letter \n");
    printf("I'll congratulate you for guessing it. \n");
    printf("If you get bored, type control-d instead. \n");
}
```

The brace at the end of line D indicates that a compound statement follows, just as a brace introduced a compound statement in previous examples. The closing brace for the if is on line G and is directly under the i of the if.

The statements on lines E and F are executed if the character entered was an e. The first not only congratulates the user on the correct guess but points to the correct letter on the line the user typed. (This extra touch is meant to suggest a level of human interface being found in more and more programs and is by no means state of the art. For example, if your erase character is # and you erase characters before typing the correct one, the arrow will be meaningless. Try rewriting this example to get around this problem. Next month, in the section on character arrays, I will present some ideas that may be helpful.)

The break on line F is a powerful statement in C. It causes the program to break out of the first enclosing while, for, do, or switch (I've omitted discussion of the do statement here but will present switch in part 2), passing control to the statement following. In this case, the break causes the while to release control, with processing resuming just after the brace on line H, so the program next reaches the closing brace for main and ends.

We have wandered through C programs to learn C program structure, C functions within programs, basic input/output in C, variables and assignment of value, and control constructs such as while, for, if, and else. With these five aspects of C you can write useful programs so long as you are processing one character at a time.

Next month in part 2 we will take up the more advanced topics of arrays, pointers, communication between C programs and the host operating system, and the important concept of tool building.■

James Joyce is president of International Technical Seminars Inc. (520 Waller St., San Francisco, CA 94117) and founder of the Unix Bookstore.

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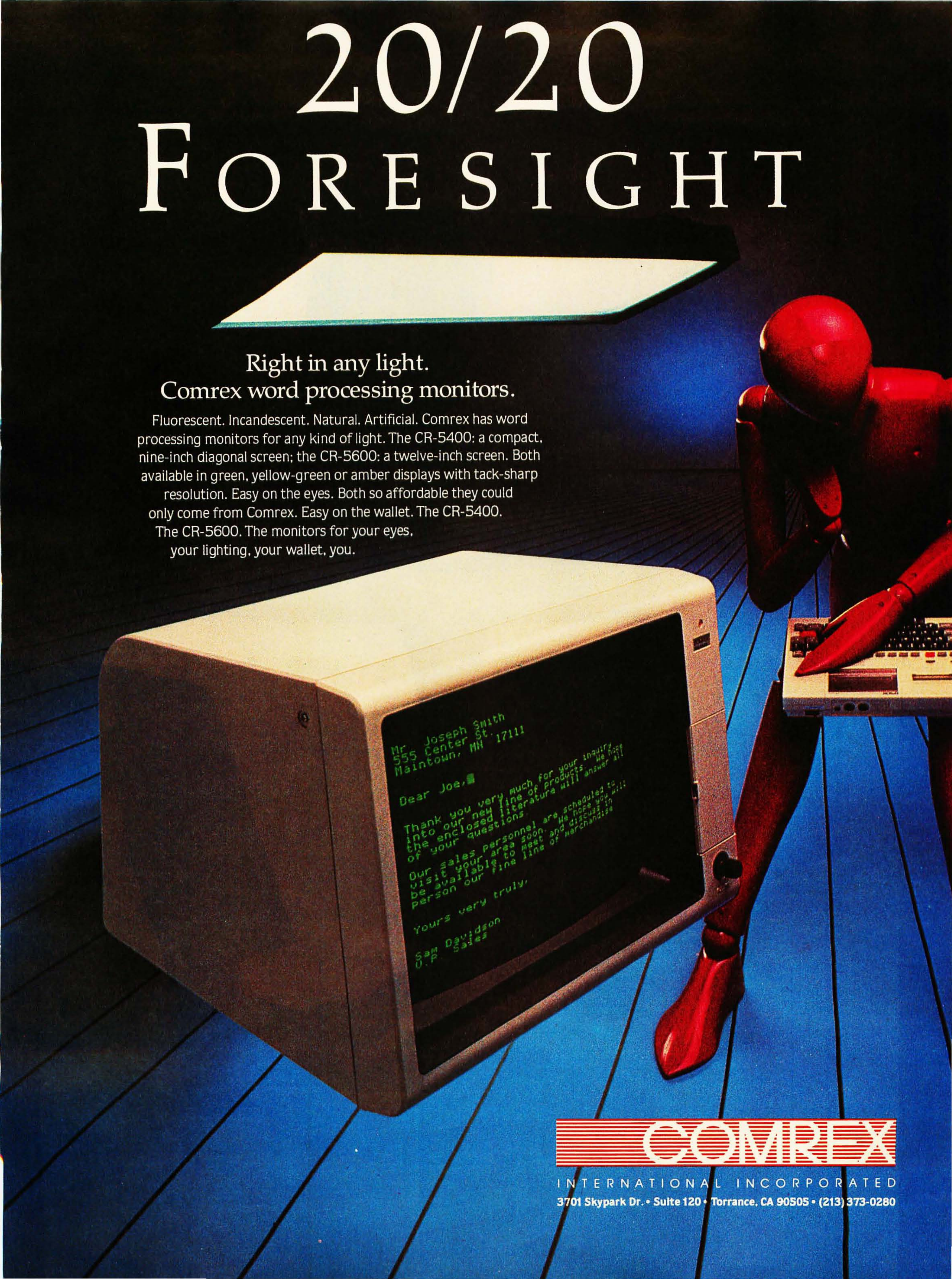
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Comparing C Compilers for CP/M-86

Portability, compactness, and speed are crucial

by Jerry Houston, Jim Brodrick, and Les Kent

The very number of C compilers available attests to the strong position C has taken as the shift toward 16-bit microprocessors picks up momentum. The popularity of Intel's 8086 family of microprocessors (in combination with Digital Research's CP/M-86, MP/M-86, and Concurrent CP/M-86) prompted us to wonder, of the C compilers currently available for these systems, which are best for a particular purpose, which are most cost-effective, and which are easiest to use? Portability, compactness, and speed are crucial, but so are completeness of implementation and the extent to which the compilers make special allowances for the architecture of the 8086 processor family and the structure of CP/M.

Why C?

Long revered in the halls of academe, C has recently become a significant language in professional circles. C is fast, efficient, versatile, and, perhaps more than any other significant language, portable. C's tendency to reduce projects to a collection of discrete functions is well suited to joint programming efforts and produces code that is easy to maintain.

In the rush to migrate to 16-bit processors, software houses are turning to C in droves (see the text box "The 16-Bit Migration," page 84). It has qualities in addition to its speed that make it particularly suited for systems programming (e.g., flexible pointers and efficient use of registers). Thomas Plum in *Learning to Program in C* (Cardiff, NJ: Plum Hall Inc., 1983) calls it "a portable assembler." Yet, C nicely accommodates applications programming by inducing its users to practice structured programming techniques.

Our evaluation is slanted toward identifying the suitability of these six C compilers for use by a systems house.

One software house newly committed to the C language is Digital Research Inc. (DRI), whose CP/M operating system dominates the 8-bit world and whose operating systems are a major force in the 16-bit world. DRI has announced that, in order to achieve source-code portability, all new CP/M operating systems will be written in C.

A great attraction of the Digital Research family of operating systems is that it spans the gap between 8- and 16-bit processors. In other words, a data file that can be read on an 8-bit CP/M system can also be read on a 16-bit one. And DRI has announced that future versions of CP/M will support National Semiconductor's 16032 and Zilog's Z8000 microprocessors.

Evaluation Philosophy

We approached our evaluation of six C compilers (Mark Williams CC86, Digital Research C, Computer Innovations C86, Mark DeSmet C, Lattice C, and Supersoft C) with a slant toward identifying their suitability for use by a systems house because we work for one. (That means we make operating computers out of a lot of interconnected parts.) We are more interested in using C as a systems language to produce device handlers, formatters, diagnostics, and utilities than we are in using it to produce accounting programs and database managers.

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The 16-Bit Migration

The microcomputer industry is going through a software cataclysm that has no parallel in the minicomputer world. Three major manufacturers—Intel, Motorola, and Zilog—have all produced 16-bit processors that are incompatible at the object-code level with their popular 8-bit counterparts. A fourth manufacturer, National Semiconductor, with no significant 8-bit following, has produced yet another 16-bit orphan.

In the minicomputer world, this would have been considered a classical, almost comical, marketing error: an entire generation of processors has been cut off. Huge user bases with millions of man-hours of software development and user training have been abandoned during the industry's transition from 8 to 16 bits.

This situation has sparked a great migration. Masses of software are suddenly being uprooted from their 8-bit homes by a relentlessly advancing technology and forced to resettle in strange and hostile 16-bit lands dominated by the 8086, the 68000, the Z8000, and the 16032.

Operating systems, peripheral drivers, languages, and application programs are struggling to reestablish themselves in new, fiercely competitive environments. The reward for the first products to make a successful transition from 8 to 16 bits will be what marketing sages call "positioning"—which translated means popular acceptance, loyal followers, a place in the sun. The penalty for delay is catastrophe.

The migration path must be well chosen. Companies with products written in assembly language are finding that their fast, sleek 8-bit code, which took so long to write and debug, will require a frightening amount of time to be reproduced in a 16-bit environment. The time spent in a major assembly project costs more than programmers' salaries. The major cost is in lost opportunity.

Even more dismaying for the assembly-language folks is that their programs will have to be translated anew for, not just one, but a whole flock of attractive target processors: the 8086, the 68000, the Z8000, and the 16032. Which one would you bet on? Would you bet your company on just one of them?

The great advantage of assembly language—speed and compactness—is a luxury few can afford now that nearly all software projects are time critical. In this virgin market, you don't need fast products; you need products fast.

Companies with products written in exotic, high-level languages like PL/I, on the other hand, are in a slightly better situation. The development time spent on their 8-bit products will carry over to 16-bit versions, which should require no more than a little fine-tuning to become marketable. These companies need only sit back and wait for 16-bit versions of their chosen compiler to be released. Yep, just sit back and wait, and wait. . . .

Dennis M. Ritchie (Prentice-Hall Software Service, 1978) as the standard definition of the C language. (In an attempt to buck convention, we will try to avoid the use of the word "robust" and will resist all temptations to make puns about C.)

The Procedure

We have tested the six C compilers that are curently commercially available for the CP/M-86 operating system (although by the time this article is published, we expect four more to become available). To evaluate the speed of each compiler, we selected five benchmarks—each chosen to test a certain range of C language features. Not all the compilers were able to run all the benchmarks. After spending many hours trying to find source code that was common to all the compilers, we finally decided that documenting the inability to compile a legitimate program provides useful information about a compiler.

These benchmarks were performed on a Compupro system with a 10-MHz 8086 and a 4-megabyte semiconductor disk emulator (Compupro's MDrive/H). The 8087 floating-point benchmarks were run at 5 MHz to allow for the slower speed of the 8087 math processor. The operating system used was our own implementation MP/M-86.

The Sieve of Eratosthenes is a mandatory benchmark—if nothing else, it tests a compiler's ability to perform loops.

The four performance categories we measured (see table 1) in these benchmarks were (1) compile time on a floppy disk and on a disk emulator (or memory drive), (2) link time on a floppy disk and on a disk emulator, (3) absolute size of executable object code produced, and (4) execution time of compiled code (run on a disk emulator).

For the first three benchmarks, we also measured the effective size of the code generated by each compiler. We derived this value by measuring the absolute size of the code produced by compiling a program with only an empty printf function call—the only function call used in the first three benchmarks. We then subtracted this value from the size of the absolute code produced by the benchmark in question. The resulting value represents the amount of incremental code generated to run the specific benchmark.

Using the effective code size gives a much more accurate picture of a compiler's code-generation efficiency than merely looking at the size of the executable file created by compiling a given benchmark. The size of the fixed portion of a program may indicate only how elaborate the library is. As your C programs grow larger, only the amount of incremental code will increase. (Note in table 1, for example, that, although the command files produced by the DRI compiler are bigger than the Computer Innovations files, Digital Research has an edge in effective code size. This suggests that the DRI compiler will

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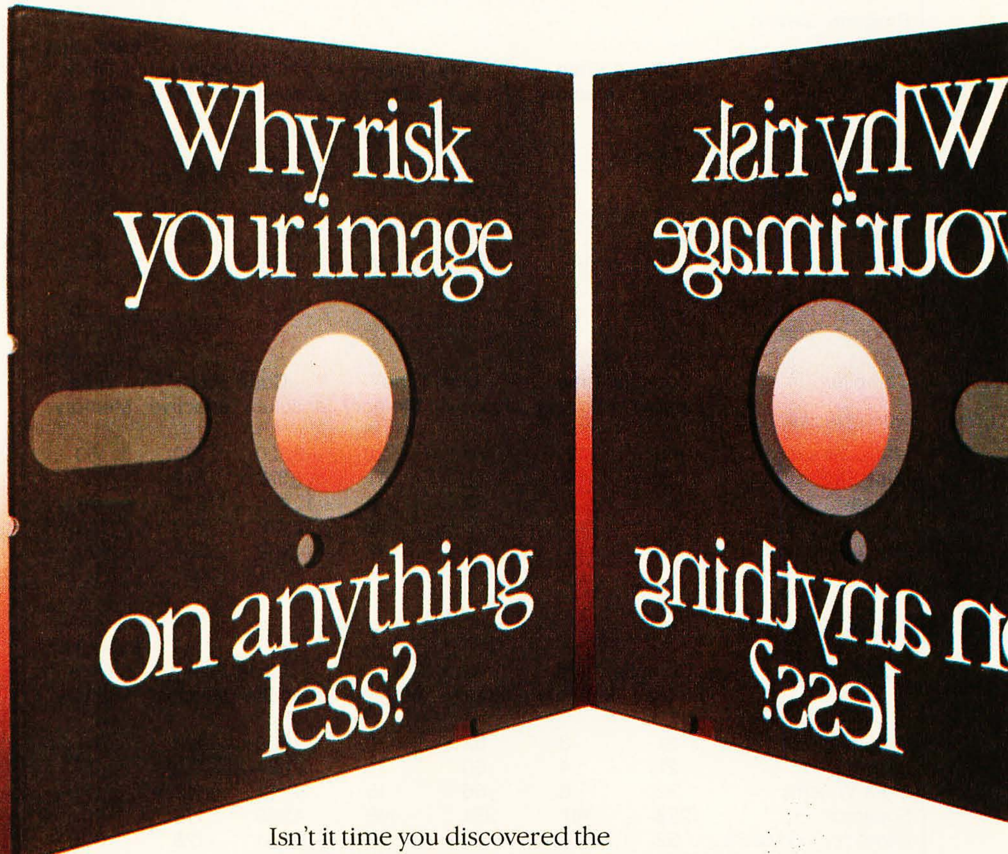

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actually produce smaller programs than Computer Innovations C86 once the source program reaches a certain size.)

Quick Results

The sieve benchmark in listing 1 is a mandatory test (used by Jim and Gary Gilbreath in "Eratosthenes Revisited: Once More Through the Sieve," in the January 1983 BYTE, page 283); if nothing else, it tests a compiler's ability to perform loops. All C compilers we tested ran this program, even if they ran no other. Lattice C was the undisputed champion in this classic benchmark, taking just 3.6 seconds to complete 10 iterations. Digital Research's C compiler for the 68000 performed this test in 6.0 seconds on an 8-MHz 68000 system, which would put it in fourth place, 1.1 seconds behind the Digital Research 8086 C compiler.

Program: sieve.c

Compiler	Compile Time Floppy	Compile Time Memory	Link Time Floppy	Link Time Memory	Code Size absolute	Code Size effective	Execution Time Memory
Lattice	23	4	60	10	9,984	128	3.6
Mark DeSmet	20	3	32	5	4,992	128	4.1
Digital Research	32	8	64	12	13,888	144	4.9
Mark Williams	29	6	67	22	7,744	144	6.2
Computer Innovations	31	7	49	20	11,888	208	9.4
Supersoft	253	142	266	148	5,200	416	12.0

Program: sort.c

Compiler	Compile Time Floppy	Compile Time Memory	Link Time Floppy	Link Time Memory	Code Size absolute	Code Size effective	Execution Time Memory
Mark Williams	45	12	84	22	8,320	720	50
Mark DeSmet	35	9	49	11	5,376	512	66
Lattice	36	6	82	15	10,496	640	79
Computer Innovations	46	15	71	38	12,416	736	146
Digital Research	43	14	59	12	14,432	688	199

Program: fibo.c

Compiler	Compile Time Floppy	Compile Time Memory	Link Time Floppy	Link Time Memory	Code Size absolute	Code Size effective	Execution Time Memory
Mark DeSmet	21	3	32	5	4,992	128	14
Lattice	21	4	60	11	9,984	128	15
Mark Williams	32	6	66	15	7,712	112	17
Supersoft	238	141	251	146	4,960	176	19
Computer Innovations	32	7	50	13	11,808	128	22
Digital Research	37	9	55	12	13,856	112	25

Program: float.c

Compiler	Compile Time Floppy	Compile Time Memory	Link Time Floppy	Link Time Memory	Code Size	Execution w/o 8087	Time w/8087
Lattice	22	4	65	11	11,136	95	n/a
Mark DeSmet	22	3	34	5	5,248	108	15.5
Digital Research	35	9	60	13	15,824	116	11.8
Mark Williams	34	8	70	25	8,320	167	n/a
Computer Innovations	29	6	48	19	12,080	278	32.6

Program: Iofile.c

Compiler	Compile Time Floppy	Compile Time Memory	Link Time Floppy	Link Time Memory	File Size Code	Execution Time Floppy	Execution Time Memory
Lattice	31	7	72	14	10,496	218	29
Mark DeSmet	26	4	39	7	9,856	592	37
Mark Williams	43	11	78	20	8,624	654	40
Digital Research	42	13	60	13	16,928	656	64
Computer Innovations	37	11	56	19	13,200	682	76

Table 1: *Results of the benchmark tests.*

Not all the C compilers that we tested support floating-point operations. Of those that do, not all support the transcendental functions (trigonometric, logarithmic, exponential, etc.). Thus, the philosophy behind the floating-point benchmark (see listing 2) is to keep things simple and minimize the time spent looping; the only floating-point operations we measured were multiplication and division.

Comparison of the compilers' mathematical ability is complicated by Intel's phenomenal math processor, the 8087. While it meets the IEEE's (Institute of Electrical and Electronics Engineers) 80-bit floating-point standard and is potentially as much as 100 times faster than equivalent software, the peculiarities of Intel hardware design require that the processor with which the 8087 is paired run at the same clock speed. The fastest 8087 currently available in production quantities runs at 5 MHz, yet 8088s that run at 8 MHz are readily available, as are 10-MHz 8086s. This means that the main processor must be slowed down by as much as 50 percent, incurring a corresponding loss in system throughput, in order to take advantage of the 8087 math processor.

With systems capable of handling high-speed processors, you must decide whether going faster while number crunching (between 7 and 10 times faster on the compilers tested) is worth sacrificing as much as half your speed while doing anything else. Lattice C was the "pure-software" winner, running the floating-point benchmark in 95 seconds by itself, but Digital Research's compiler, with the aid of an 8087, was an order of magnitude faster than that. (An advantage of the IBM Personal Computer is that its 8088 processor runs at about 4.77 MHz, so that the decision to add an 8087 is

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Listing 1: *The Sieve of Eratosthenes benchmark developed by Jim and Gary Gilbreath as a standard for comparing the speed of various computer systems.*

```
/* Eratosthenes Sieve Prime Number Program in C from Byte January 1983 */

#define true 1
#define false 0
#define size 8190

     char flags[size+1];
main ( )
     {
     int i,prime,k,count,iter;

     printf("10 iterations\n");
     for(iter = 1; iter <= 10; iter++)       /* do program 10 times */
          {
          count = 0;                         /* prime counter */
          for (i = 0; i <= size; i++) /* set all flags true */
                flags[i] = true;
          for (i = 0; i <= size; i++)
               {
                    if (flags[i])            /* found a prime */
                    {
                    prime = i + i + 3;       /* twice index + 3 */
/*                  printf ("\n%d", prime);  */
                    for (k=i+prime; k<=size; k+= prime)
                         flags[k] = false;       /* kill all multiples */
                    count++;                     /* primes found */
                    }
               }
          }
          printf("\n%d primes.", count);/* primes found on 10th pass */
     }
```

Listing 2: *Floating-point benchmark. This simple program tests the speed of floating-point functions in C compiler libraries. Compared to the number of multiplications and divisions in this program, the time spent executing the looping instructions is insignificant.*

```
/* simple benchmark for testing floating point speed of c libraries
   does repeated multiplications and divisions in a loop that is
   large enough to make the looping time insignificant
   */

#define CONST1 3.141597E0
#define CONST2 1.7839032E4
#define COUNT 10000

main ( )
      {
      double a, b, c;
      int i;

      a = CONST1;
      b = CONST2;
      for (i = 0; i < COUNT; ++i)
              {
              c = a * b;
              c = c / a;
              c = a * b;
              c = c / a;
              c = a * b;
              c = c / a;
              c = a * b;
              c = c / a;
              c = a * b;
              c = c / a;
              c = a * b;
              c = c / a;
              c = a * b;
              c = c / a;
              }
      printf ("Done\n");
      }
```

simply a budgetary one.)

A word about future processors and the 8087: Intel has announced a solution to this problem in the design of its new 80286 processor, which runs at a clock speed different from that of its 80287 math coprocessor. According to Intel, the 80286, which can execute all 8088 and 8086 instructions, can execute those instructions up to six times faster than the 8086 (a conservative figure might be four times faster). Perhaps soon, the first significant digit in our benchmark times will be behind a decimal point.

The sort program in listing 3 is designed as a general test of compiler efficiency. It uses a random-number generation algorithm to produce an array of long integers, which are then sorted using a quicksort algorithm. The Mark Williams CC86 compiler won this benchmark by a significant margin.

The Fibonacci number generator in listing 4 is a reasonably good test of recursive function calls. This benchmark, which saw Mark DeSmet C barely edge out Lattice C for first place, had the tightest performance grouping of any of the benchmarks run. The Digital Research 68000 C compiler performed this benchmark in 16.8 seconds, which earned it a third place, 7 seconds ahead of DRI's 8086 C compiler.

The efficiency of low-level (unbuffered) file I/O (input/output) is tested by the program in listing 5. It almost turned out to be the "unbenchmark." We had to struggle to come up with code that most of the compilers could handle. The Lattice and Mark DeSmet Cs wouldn't run this benchmark as it was initially written using high-level I/O functions because these Cs only support low-level disk I/O. When we changed the benchmark to low-level operation, Mark Williams C dropped out because it uses only high-level I/O.

Originally the program wrote 128K bytes onto the disk, but a bug in our (beta release) DRI compiler would not allow writing of files over 64K bytes long, so we changed the file size to just under 64K bytes. The Supersoft compiler couldn't handle the long data types—a problem we

Text continued on page 94

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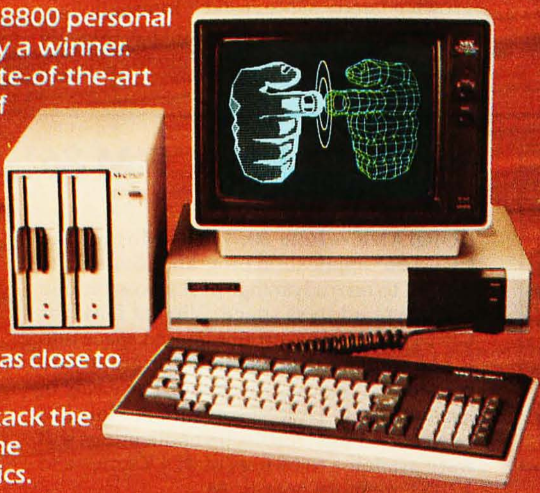

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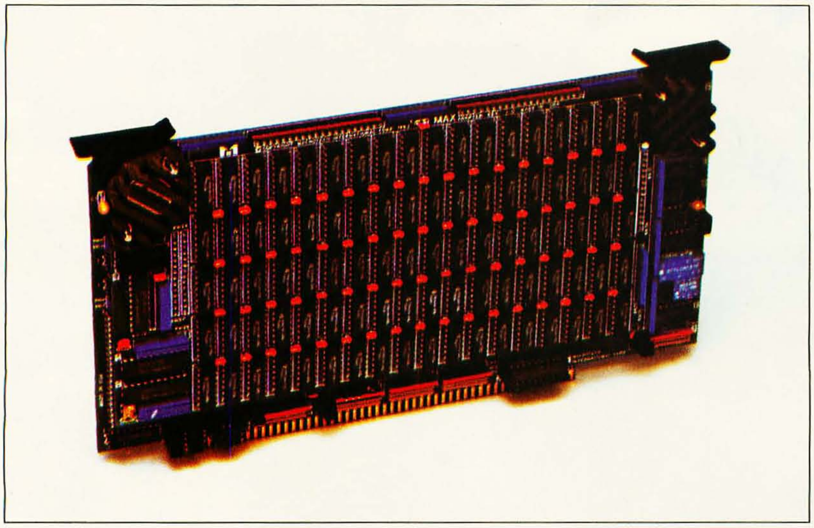

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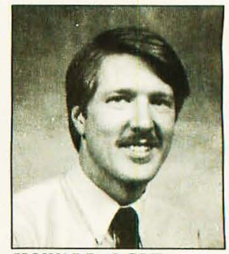
This special version is available only through Soft Machines of Champaign, IL. (217) 351-7199. Howard Ogle of Soft Machines stated, "The new **AM-*MAX*1** runs full speed with all three Alpha S100 machines." Ogle also said, "The **AM-*MAX*1** is not only the most economical memory for Alpha, but the most versatile as well. The system is even faster with Soft Machines' 'GO FAST' disk cache utilities."



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BURBANK—June 30, 1983—"Many current operating systems permit ***MAX*** to double as both virtual disk and system memory," stated Dan West of Westcom Systems. As an example, an MP/M 2.1* system using ***MAX*-M** could be configured as a 512K system memory and a 512K Vdisk. A typical CP/M 3.0* configuration could be 256K of system memory and up to 768K Vdisk. CP/M 2.2* of course, only permits a 64K system memory, leaving the balance for a virtual disk. With ***MAX***, or the **128ST**, both functions can run simultaneously in a single memory board.

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CHATSWORTH—June 30, 1983—Macrotech has moved to larger facilities located at 20630 Lassen St., Chatsworth, CA 91311. The new phone number is (213) 700-1501. "Due to a healthier marketplace and a phenomenal demand for the ***MAX*** series, larger facilities were necessary. This permits additional staffing, increased production, and customer support levels," said Mike Pelkey, President of Macrotech.

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BURBANK—June 30, 1983—Most of the CP/M 86* application programs available today fail to take advantage of the possible one megabyte address space. Virtual Disk for CP/M 86* will convert this unused space into RAM resident disk capacity for greatly improved disk access processing. The easily installed Virtual Disk 86 software module has been added to Macrotech's applications software available to owners of ***MAX*** series and **128ST** memory boards.

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Listing 3: *The sorting benchmark. This program creates an array of random long integers, then performs a quicksort on them. In this example, the number of elements in the array is set by MAXNUM, and the number of times the program is performed is set by COUNT.*

```
/* sorting benchmark--calls random the number of times specified by
   by MAXNUM to create an array of long integers, then does a quicksort
   on the array of longs. The program does this for the number of times
   specified by COUNT.
*/

#include "stdio.h"

#define MAXNUM 1000
#define COUNT 10
#define MODULUS ((long) 0x20000)

#define C 13849L
#define A 25173L

long seed = 7L;

long random( );

long buffer [MAXNUM] ={0};

main ( )
        {
        int i, j;
        long temp;

        printf ("Filling array and sorting %d times\n", COUNT);
        for (i = 0; i < COUNT; ++i)
                {
                for (j = 0; j < MAXNUM; ++j)
                        {
                        temp = random (MODULUS);
                        if (temp < 0L)
                                temp = (-temp);
                        buffer [j] = temp;
                        }
                printf ("Buffer full, iteration %d\n", i);
                quick (0, MAXNUM, buffer);
                }
        printf ("Done\n");
        }

quick (lo, hi, base)
        int lo, hi;
        long base [];
        {
        int i, j;
        long pivot, temp;

        if (lo < hi)
                {
                for (i = lo, j = hi, pivot = base [hi]; i < j; )
                        {
                        while (i < j && base [i] < pivot)
                                ++i;
                        while (j > i && base [j] > pivot)
                                --j;
                        if (i < j)
                                {
                                temp = base [i];
                                base [i] = base [j];
                                base [j] = temp;
                                }
                        }
                temp = base [i];
                base [i] = base [hi];
                base [hi] = temp;
                quick (lo, i - 1, base);
                quick (i + 1, hi, base);
                }
        }

long random (size)
        long size;
        {
        seed = seed * A + C;
        return (seed % size);
        }
```


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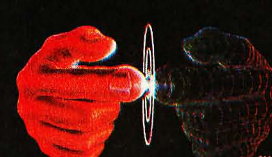

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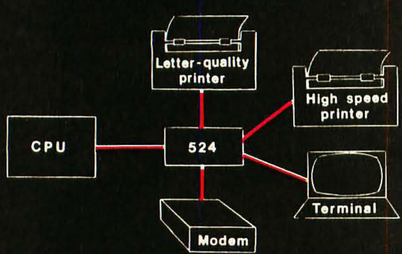

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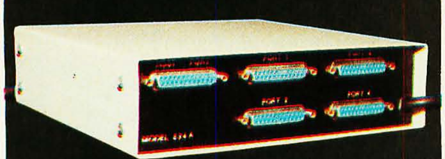

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Listing 4: *The Fibonacci series benchmark. This program tests the efficiency of a compiler's recursion by calculating a 16-bit Fibonacci number.*

```
#include        "stdio.h"

#define NTIMES  10      /* number of times to compute fibonacci value */
#define NUMBER  24      /* biggest one we can compute within 16 bits */

main( )
     {
     int i;
     unsigned value, fib( );

     printf("%d iterations: ", NTIMES);

     for (i = 1; i <= NTIMES; i++)
          value = fib(NUMBER);

     printf("fibonacci(%d) = %u.\n", NUMBER, value);
     exit(0);
     }

unsigned fib(x)         /* compute Fibonacci number recursively */
int x;
     {
     if (x > 2)
          return (fib(x - 1) + fib(x - 2));
     else
          return (1);
     }
```

Listing 5: *Disk file I/O benchmark, which sequentially writes a 65,000-byte file on disk. It then uses randomly generated long integers (modulo 65,000) as a disk address, from which it reads, then writes, a random-length string of bytes. This exercises the file I/O functions of the compiler.*

```
/* file reading and writing benchmark
   sequentially writes a 65000 byte file on disk
   generates random long integers
   uses these modulo 65000 to read and write strings of ODDNUM bytes
   with the file handling system of the c package
   the random number generator is set to a specific seed,
   so that all compilers should generate the same code
   */


#define ERROR -1
#define READERR 0

#define BEG 0
#define CURR 1
#define END 2
#define READ 0
#define WRITE 1
#define UPDATE 2

#define OKCLOSE 0
#define FILESIZE 65000L
#define COUNT 500

#define C 13849L
#define A 25173L
#define ODDNUM 23
long seed = 7L;

long random ( ), lseek ( );

main ( )
        {
        int i;
        long j, pos;
        int fd;
        char buffer [ODDNUM + 1];

        if ((fd = creat ("test.dat", WRITE)) == ERROR)
                abort ("Can't create data file\n");
        else    printf ("File opened for sequential writing\n");
```

Listing 5 continued on page 94

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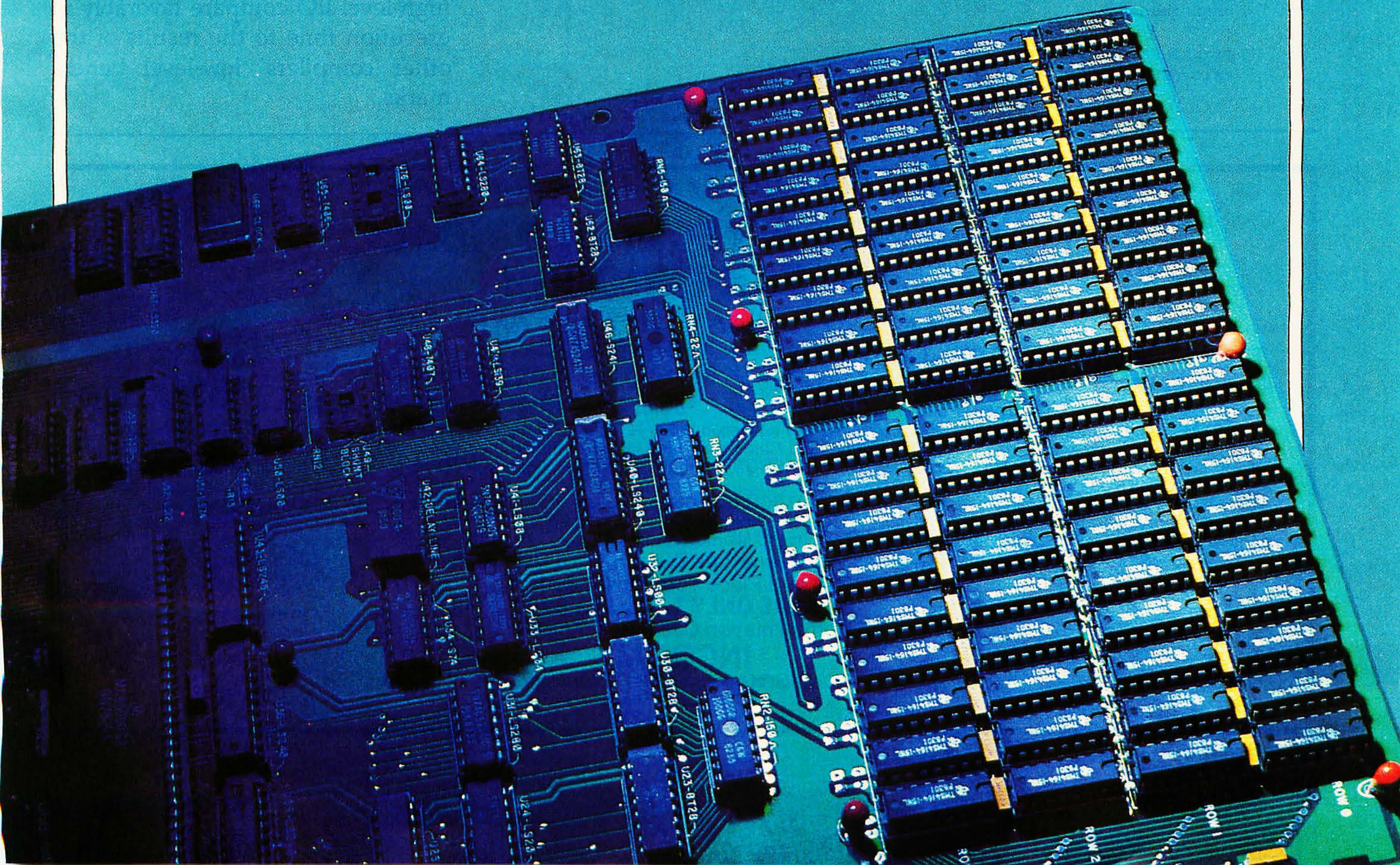


Listing 5 continued:

```
        for (j = 0; j < FILESIZE; ++j)
                if (write (fd, "x",1) == ERROR)
                        abort ("Unexpected EOF in writing data file\n");
        if (close (fd) != OKCLOSE)
                abort ("Error closing data file\n");
        else
                printf ("Normal termination writing data file\n");
        if ((fd = open ("test.dat", UPDATE)) == ERROR)
                abort("Can't open data file for random reading and writing\n");
        else    printf ("File opened for random reading and writing\n");
        for (i = 0; i < COUNT; ++i)
                {
                j = random (FILESIZE);
                if (j < 0L)
                        j = (-j);
                if (FILESIZE - j < ODDNUM)
                        continue;
                if ((pos = lseek (fd, j, BEG)) == -1L)
                        abort ("Error seeking to random offset\n");
                if (read (fd, buffer, ODDNUM) == READERR)
                        abort ("Error reading at random offset\n");
                j = random (FILESIZE);
                if (j < 0L)
                        j = (-j);
                if (FILESIZE - j < ODDNUM)
                        continue;
                if ((pos = lseek (fd, j, BEG)) == -1L)
                        abort ("Error seeking to random offset\n");
                if (write (fd, buffer, ODDNUM) == READERR)
                        abort ("Error writing at random offset\n");
                }
        if (close (fd) != OKCLOSE)
                abort ("Error closing data file\n");
        else
                printf("Normal termination from random reading and writing\n");
        }

long random (size)
        long size;
        {
        seed = seed * A + C;
        return (seed % size);
        }

abort (message)
        char *message;
        {
        printf (message);
        exit (ERROR);
        }
```

Text continued from page 88:

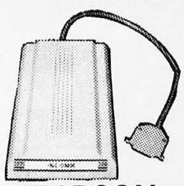
could see no easy way around—so it sat on the bench.

Because the Mark Williams compiler does not support low-level I/O, we compiled a special version of the program that has the same algorithm but uses high-level function calls (fread instead of read, fwrite instead of write). We assumed that this would be slow but would at least work. Amazingly, Mark Williams C finished third. Scoring a hat trick, Lattice took this benchmark as well.

Let's take a closer look at the compilers (see also table 2).

Mark Williams CC86

CC86 has the most professional *feel* of any package we tested. It makes a good attempt at full Kernighan and Ritchie and Unix version 7 compatibility. Of all the compilers, CC86 is by far the most efficient at using buffered I/O functions such as fopen, fread, and fseek (high-level I/O functions). On the other hand, CC86 does not support low-level file I/O (i.e., block I/O functions such as open, read, lseek). This decreases its portability (we couldn't run our low-level benchmark) but in no way reduces CC86's ability to function. In fact, CC86's benchmark results in high-level I/O compare favorably in execution time to the results of the other compilers' low-level benchmarks.



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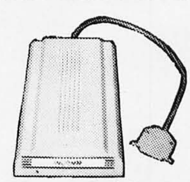

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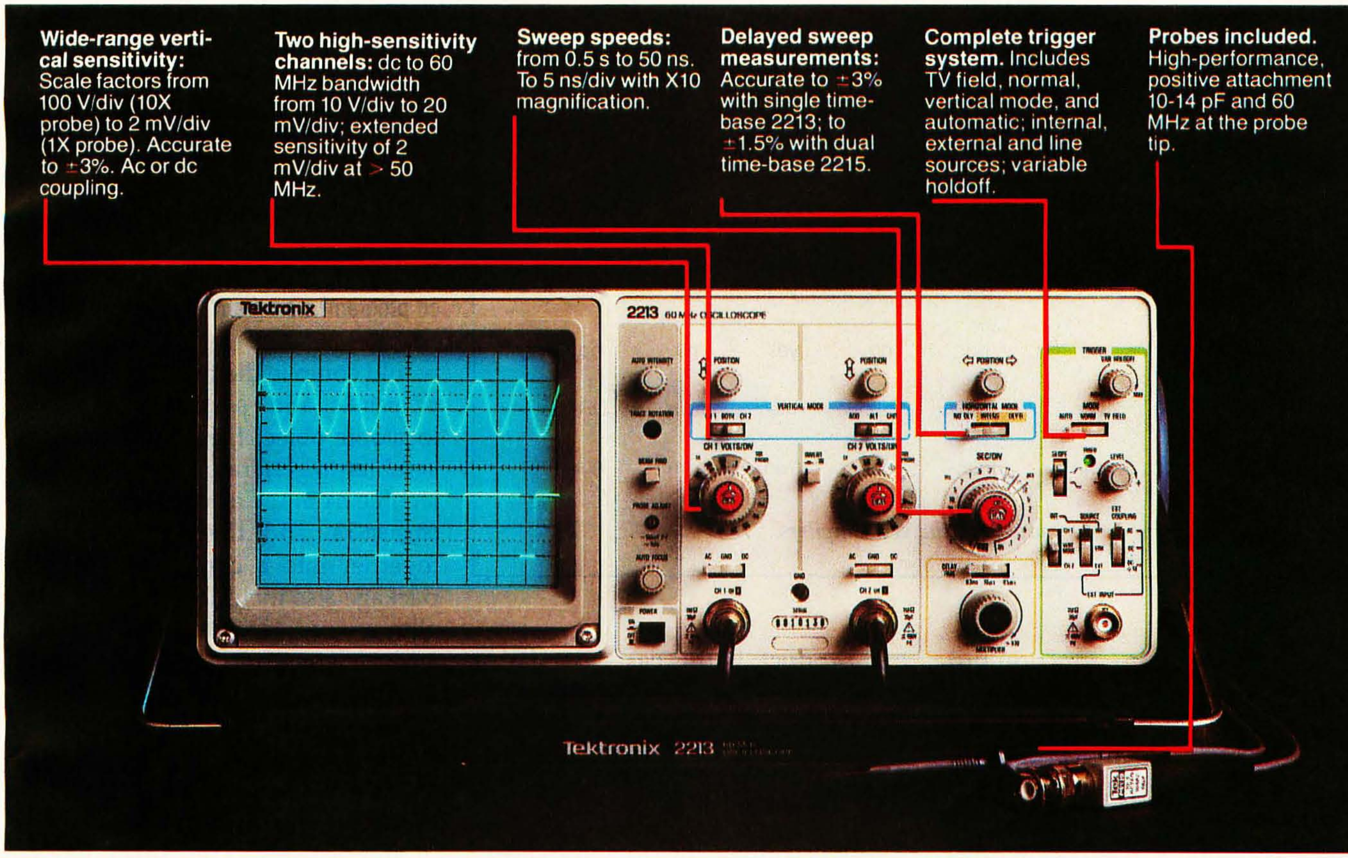

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Feature	Computer Innovations	Digital Research	Lattice	Mark DeSmet	Mark Williams	Supersoft
Number of Passes	3	3	2	2	4	3
Source for Library	yes	no	no	no	no	yes
8080 Model	no	no	no	no	yes	yes
Small Model	yes	yes	yes	yes	yes	yes
Medium Model	no	yes	no	no	no	no
Compact Model	no	yes	yes	no	no	no
Big Model	no	yes	no	no	no	no
Initialization	yes	yes	yes	yes	yes	no
Bit Fields	yes	yes	yes	yes	yes	no
Register Variables	yes	yes	no	yes	yes	no
Floating Point	yes	yes	yes	yes	yes	no
8087 Support	yes	yes	no	yes	no	no
Overlay Manager	no	yes	yes	no	no	no
Produces Assembly	no	yes	no	yes	yes	yes
In-Line Assembly	no	no	no	yes	no	no
Assembler Format	n/a	DRI	n/a	Intel	own	DRI
Relocated Format	own	Intel	Intel	own	own	n/a

Table 2: *Comparison of the features of the six compilers.*

Small Model:	64K-byte code 64K-byte data, stack, heap
Medium Model:	Unlimited code 64K-byte data, stack, heap
Compact Model:	64K-byte code 64K-byte data 64K-byte stack Unlimited heap
Big Model:	Unlimited code 64K-byte data 64K-byte stack Unlimited heap

Table 3: *Memory allocation for the four different memory sizes allowed by Digital Research's C Compiler for CP/M-86.*

CC86, tailored for production programming, is full of features that speed up the programming process and encourage portability. For example, it includes an extensive library (27K bytes) of header source files that define commonly used structures, operating-system interfaces, and memory-allocation conventions. This promotes consistency, and thus portability, between C programs within an operating system. It also saves time because most C programmers would otherwise be required to generate their own header library.

The compiler runs four passes that may be invoked individually or all at once. Its executor program is a good example of the package's orientation toward saving development time. Only CC86 and the DRI package allow you to compile and link a program in a single command line, without resorting to a submit file. Of the two, CC86 is the simpler. All the defaults are geared toward making an end product, in this case, executable object code. To compile and link the sieve benchmark, the user types

```
cc sieve.c
```

This will compile the program sieve.c, automatically build a loader directive file, and link an executable object file, sieve.cmd.

A wealth of options are available, including the ability to compile only (without linking), to produce an assembly source, and to use either the 8080 model (64K-byte total) or the small model (64K-byte code, 64K-byte data). Options allow control of disk-management directives and compile-time symbol definition, specification of stack, and dynamic allocation of memory-pool size. A wonderful so-called verbose option causes each pass to print out special statistics as it executes.

Assembly source files (with the extension .s) can be combined on the command line with C source files to produce a command file. For example, the line

```
cc program1.c program2.c program3.s
```

would compile the two C source files, program1.c and program2.c, into relocatable object files, invoke the assembler to generate a relocatable object file from the assembly source file program3.s, and then link them all together into a command file. The package also includes a librarian that allows you to create a library and to add, delete, and list library objects. All this saves development time.

The linker gives you considerable control over aligning code and data segments and can be passed arguments on the command line, in a file, or interactively. The linker has far more power than even a systems programmer is ever likely to require.

Our major complaint about the CC86 compiler is that its assembler is not Intel-compatible, which means for some applications you must learn yet another assembler. Still, this is a high-quality, professional compiler with good portability, good efficiency, and excellent speed.

Digital Research C Compiler

When Digital Research speaks, programmers listen. Digital Research has begun speaking in C. DRI's C compiler has arrived, and it is a biggie. A three-pass compiler with a ton of options, a relocating assembler that creates Intel-compatible object code,

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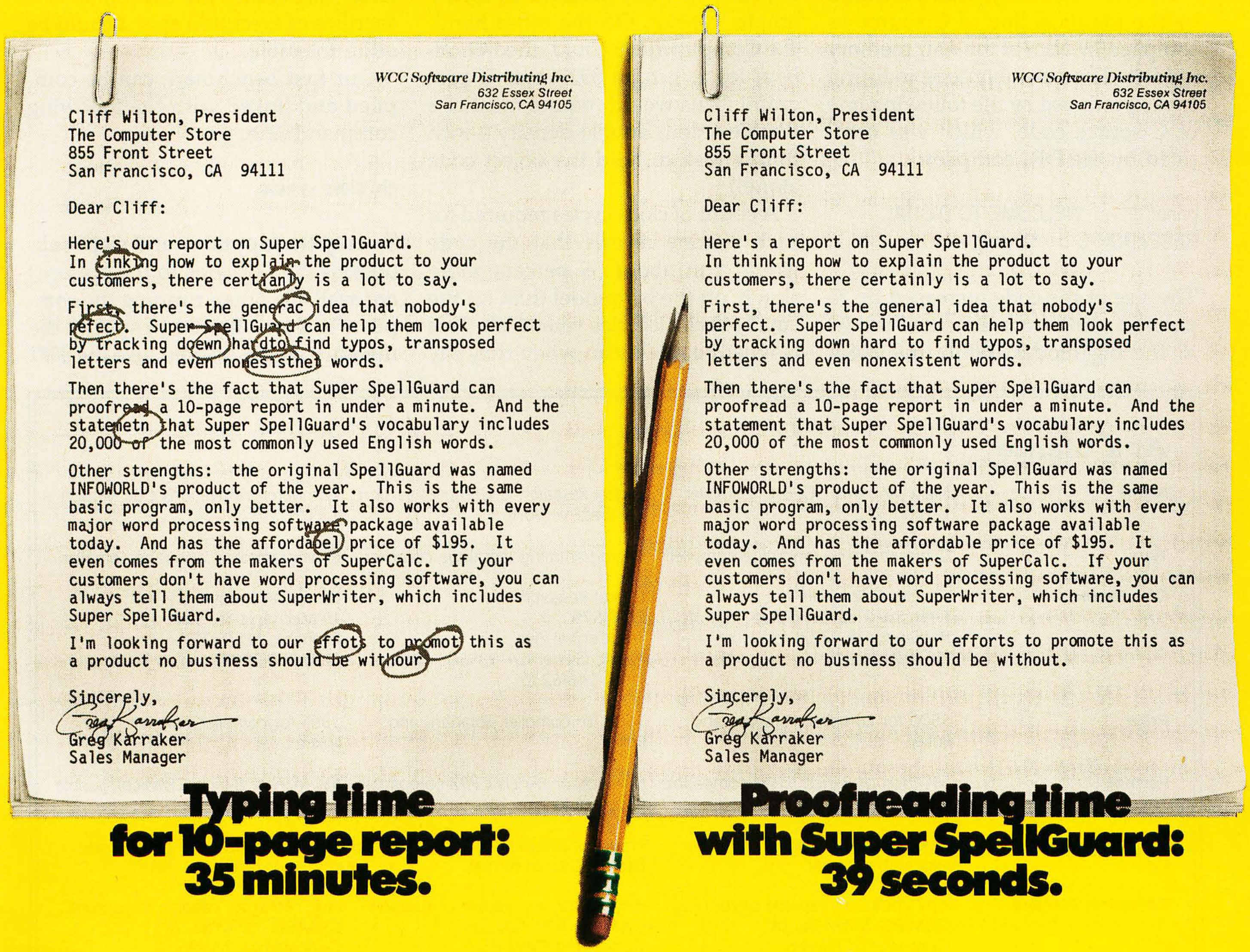

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a linker, a big library, support for the 8087, support for large amounts of memory—this compiler has it all.

This is the only compiler tested that supports four memory models, namely, small, medium, compact, and big (see table 3). This is a significant advance in the state of the art for CP/M-compatible languages because, finally, you are allowed to write really big, RAM-resident programs in a high-level language. The different models allow you to select the way memory is allocated to the code, data, stack, and heap segments of your program (the heap is a dynamically allocated data area).

Note the assembly code produced by the identical line of C source as compiled by each of the four memory models. The assembly code in listing 6 was produced by the following line of C source code, which was compiled by the DRI compiler:

```
printf("**        WELCOME TO DIGITAL
RESEARCH C       ** \ n");
```

The size of the code increased by 75 percent going from the small model to the big model. While the 8088/8086-type processor can address a maximum of 1 megabyte of RAM (random-access read/write memory), not all machines that can run CP/M-86 can hold that much memory. The ubiquitous IBM PC, for example, cannot. On the other hand, the Compupro 816 could, theoretically at least, run an 832K-byte C program! (This would require most of a double-sided, double-density 8-inch floppy disk to hold the object code alone.)

A count of clock cycles required for each routine reveals that the code would run about 36 percent more slowly on the big model than on the small (42 clock cycles versus 57). This is what people mean when they say that the peculiar architecture of the 8088/8086 family makes it awkward to take advantage of its 1-megabyte address space. Fortunately, the 8088/8086 family from Intel keeps getting faster (especially the 80286), so this sacrifice of execution speed could be quite tolerable.

Our first benchmark can be compiled and linked with the following command line:

```
drc sieve -asieve
```

Twenty-three options and eight suboptions (i.e., options to the options) are available when running the compiler. You are allowed to specify the memory model desired, use the 8087

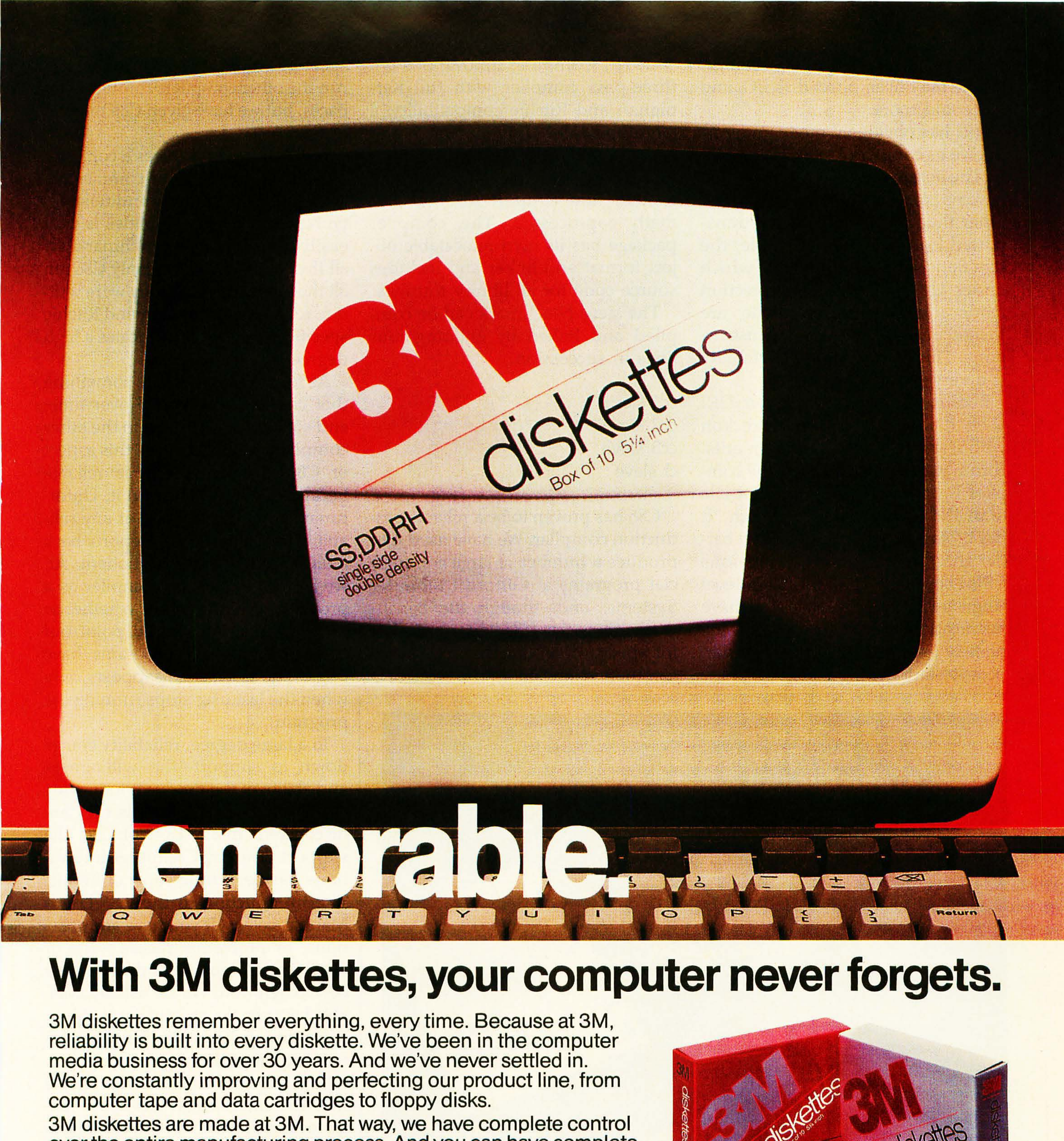
Listing 6: *Assembly code generated by Digital Research's C compiler for CP/M-86. The difference in code among the four models is caused by setting the compiler for different memory-allocation schemes.*

```
Small model      Medium Model    Compact Model          Big Model
------------------------------------------------------------------
(8 bytes)        (10 bytes)      (12 bytes)             (14 bytes)

 mov ax,0x32     mov ax,0x32     push ds                push ds
 push ax         push ax         mov ax,0x32            mov ax,0x32
 call printf     callf printf    push ax                push ax
 pop es          pop es          call printf            callf printf
                                 add word ptr sp,0x4    add word ptr sp,0x4
```

At a Glance

Name	Mark Williams CC86 C Compiler version 1.1.2	Digital Research C Compiler version 1.0 (beta version)	Computer Innovations C86 version 1.33
Type	C programming language compiler	C programming language compiler	C programming language compiler
Distributor	Control-C Software Inc. 6441 SW Canyon Court Portland, OR 97221 (503) 292-8842	Digital Research Inc. POB 579 160 Central Ave. Pacific Grove, CA 93950 (408) 646-6230	Computer Innovations Inc. 10 Mechanic St., Suite J Redbank, NJ 07701 (201) 530-0995
Price	$500 for compiler, librarian, and linker	$600 for compiler, librarian, and linker	$385 for compiler, librarian, and linker
Format	5¼-inch or 8-inch CP/M-compatible floppy disks	5¼-inch or 8-inch CP/M-compatible floppy disks	5¼-inch or 8-inch CP/M-compatible floppy disks
Type of Compiler	Produces object code in its own relocatable format	Produces assembly or object code in DRI relocatable format	Produces relocatable object code
Computer Needed	Any computer capable of running CP/M-86, MP/M-86, or Concurrent CP/M-86	Any computer capable of running CP/M-86, MP/M-86, or Concurrent CP/M-86	Any computer capable of running CP/M-86, MP/M-86, or Concurrent CP/M-86
Documentation	59-page loose-leaf manual in three-ring binder	167-page manual	12-page loose-leaf manual in three-ring binder
Audience	Systems and applications software developers, C programmers	Systems and applications software developers, C programmers	Systems and applications software developers, C programmers



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math coprocessor, generate or suppress source and assembly listings, invoke the linker, direct disk I/O, and more and more.

DRI has obviously made an effort to give its compiler Unix compatibility. The library contains functions that have no place in a CP/M environment other than to tolerate C code transported from Unix. For example, the functions chmod and chown, which under Unix change the protection mode and owner ID of a file, are treated under CP/M as no-op instructions. This concern about portability is a very heartening sign.

Because this is the compiler DRI uses, it would be a force to reckon with regardless of its intrinsic merits. Fortunately for the industry, the compiler is not only serviceable but is a dramatic software breakthrough. It has broken through the memory barrier that has caused every previous CP/M-compatible, 16-bit, high-level language to flounder. At last we have justification for going to 16 bits, namely, space. The new frontier. Scotty, start writing code!

Computer Innovations C86

C86 by Computer Innovations is a three-pass compiler with full Kernighan and Ritchie compatibility, a large library of Unix version 7 and special machine-dependent functions (the largest library of all the compilers tested), and support for the 8087 math coprocessor. The compiler package has its own relocatable object format and linker and includes source code for all library routines.

The sieve benchmark can be compiled and linked by entering four lines in succession:

```
cc1 sieve
cc2 sieve
cc3 sieve
cl sieve
```

C86 has proven to be a reliable production compiler. We have used it to produce a number of large commercial programs at Gifford Computer Systems; and, though the benchmarks show that C86 wins no medals for speed or compactness, the very fact that we are still in the black and have a reasonably satisfied clientele speaks favorably for it. We may have run the other compilers through their paces, but we have given C86 the acid test.

Two important features a compiler must have in order to be commercially useful are portability and reliability. Neither of these qualities is very easily measured in a benchmark. Of all the compilers tested, only C86 ran all the benchmarks as they were written, following Kernighan and Ritchie specifications, which indicates a high degree of portability.

As for reliability, that is something that can be judged only over time, and so it is not really fair to the other compilers tested to stress this aspect of C86. We know C86 is reliable because we have relied on it. Unfortunately, we don't know of any reliability benchmark that reports back a bug index or a glitch quotient. All we can do is use the compiler as a professional tool and see whether or not it works. We should point out that all significant programs have bugs. The last bug disappears only when the last user stops running the program.

To a large degree, reliability comes down to support—the willingness and ability of the producer to provide timely fixes to problems as they are discovered. In the case of C86, the support given by Computer Innovations has been little short of heroic. The introduction to the C86 User's Manual states: "If you have any questions, or problems, please write or call. We really do care and will do our best to help you. We are usually available between 9 a.m. and 9 p.m. Monday through Friday, and sometimes Saturday and Sunday."

Our major complaint with C86 is that the interface to assembly language is awkward, due to the lack of a relocatable assembler. This contrasts sharply with the DeSmet compiler, which actually allows in-line assembly (a feature we love). In general, the C86 compiler is a solid product with a good track record. Support is excellent, to say the least, and improved versions have been released regularly. It's good now, and it keeps getting better.

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At a Glance

Name	Mark DeSmet C Development Package version 1.5	Lattice 8086/8088 C Compiler version 1.03	Supersoft C Compiler version 1.1.5
Type of Software Package	C programming language compiler	C programming language compiler	C programming language compiler
Distributor	C Ware 1607 New Brunswick Ave. Sunnyvale, CA 94087 (408) 736-6905	Lifeboat Associates 1651 Third Ave. New York, NY 10028 (212) 860-0300	Supersoft POB 1628 Champaign, IL 61820 (217) 359-2112
Price	$100 for compiler, assembler, linker, and visual editor	$500 for compiler, librarian, and linker; $395 for linker with overlay manager	$250 for compiler; assembler and linker/loader not included
Format	5¼-inch or 8-inch CP/M-compatible floppy disks	5¼-inch or 8-inch CP/M-compatible floppy disks	5¼-inch or 8-inch CP/M-compatible floppy disks
Type of Compiler	Produces Intel-compatible relocatable object code	Produces Intel-compatible relocatable object code	Produces DRI-compatible assembly language
Computer Needed	Any computer capable of running CP/M-86, MP/M-86, or Concurrent CP/M-86	Any computer capable of running CP/M-86, MP/M-86, or Concurrent CP/M-86	Any computer capable of running CP/M-86, MP/M-86, or Concurrent CP/M-86
Documentation	106-page manual with snap-on binding	175-page, stapled manual punched with three holes	81-page loose-leaf manual in three-ring binder
Audience	Systems and applications software developers, C programmers	Systems and applications software developers, C programmers	Students interested in learning about assembly source libraries for C

Mark DeSmet C88

The C88 compiler by Mark DeSmet offers a stunning amount of bang for the buck: the $100 C88 development package is loaded with excellent features. The compiler conforms almost fully to Kernighan and Ritchie and has support for the 8087 math processor. An additional feature that is a great convenience for system programmers is support for in-line assembly-language code, using the #asm control. Also included is an Intel-compatible assembler, a fast linker, and a rudimentary librarian. And that same $100 also gets you a screen editor called SEE with a cursor-control library.

This compiler does not have the maturity and finesse of the Mark Williams C, but it is useful, it compiles faster than any of the others (probably because it has only two passes), the code it produces is fast and compact, and the package is very inexpensive. It is an ideal introduction to C programming if you want to get the feel of a real, full-feature C compiler but don't want to have to choose between C and a trip to Europe. If you're toying with the idea of taking up C, this is the way to go.

C88 does have some drawbacks: being a two-pass compiler, C88 cannot resolve references to structures and data types unless they have been previously initialized. Some high-level I/O functions such as fread, fwrite, and fseek are not included. Also, the librarian is primitive (it doesn't let you delete routines, only add them). These are by no means fatal flaws. We have completed some major production work using C88 and have been delighted with the extent to which its fast compilations speed up development time.

The sieve benchmark can be compiled by typing

```
C88 sieve
```

An executable object file is created by typing:

```
BIND sieve
```

Using a submit file on a memory drive, the sieve program was compiled, linked, and run in 10 seconds!

This compiler's price tag of $100 is startling and may, unfortunately, hurt its sales. It might be difficult to convince dealers to carry this compiler because the profit on a $100 sale barely pays for one invoice and one support call. Also, a low price is often associated with poor *credibility.* We are not recommending that C Ware raise its price, we are recommending that people buy the compiler—look at the benchmark results. The Mark DeSmet C compiler consistently took second place, except when it took first.

Lattice 8086/8088 C Compiler

The Lattice compiler may be the one for you if you need code that really flies. Using the Olympic scoring system, Lattice was the overall winner in our benchmark speed trials (three golds, a silver, and a bronze). The powerful two-pass Lattice compiler supports full Kernighan and Ritchie (with the exception of register variables as of now) and produces Intel-compatible relocatable object code. This code can then be linked using Plink86, a remarkably versatile linkage editor from Phoenix Software Associates.

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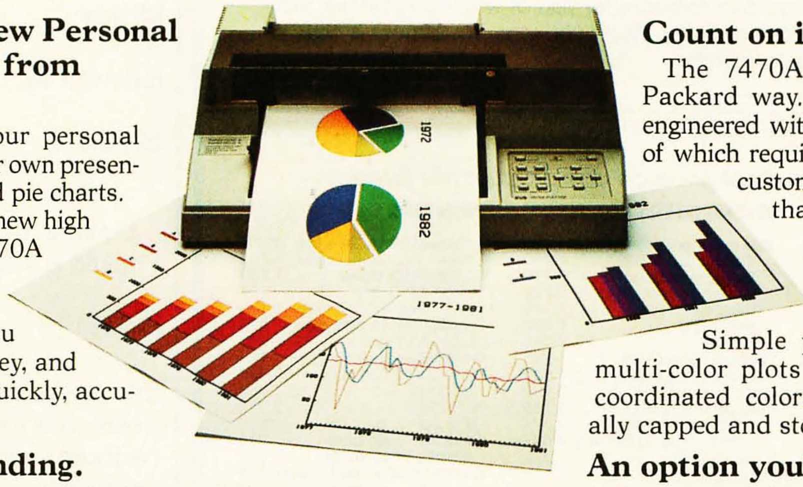

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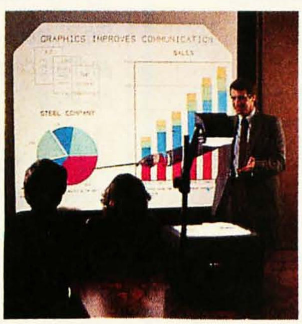

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The library included with the compiler implements a large subset of the Unix version 7 C library and contains a number of useful non-Unix functions as well. Because the library does not include the buffered I/O functions fread or fwrite, we were unable to run the high-level file I/O benchmark.

Our sieve program can be compiled by entering

```
lc1 sieve
```

followed by

```
lc2 sieve
```

Linking the sieve program with Plink86 is a little trickier. You type

```
Plink86n
```

then, when the => (prompt) appears, you enter the following lines (without waiting for any intervening prompt):

```
output sieve.cmd
section code group pgroup
file c, sieve
section data max 1000h group dgroup
lib lc.lib
```

The Plink86 linker is not the simplest linker we have ever seen, *but it* appears to be able to do everything except write articles. One reason linking a C program with Plink86 is so complex is that unlike, say, the Mark Williams linker, Plink86 is a general-purpose product and so its defaults are not designed to make it easy to link CP/M-86-compatible C programs.

A great advantage to using the Plink86 linker is that its extended version (which costs an additional $395 above the price of the standard compiler/linker package) has a transparent overlay manager for creating programs with more than 64K bytes of code (the most code possible without using overlays). This feature allows you to create programs that will load library routines from disk as needed during program execution. The Digital Research compiler is the

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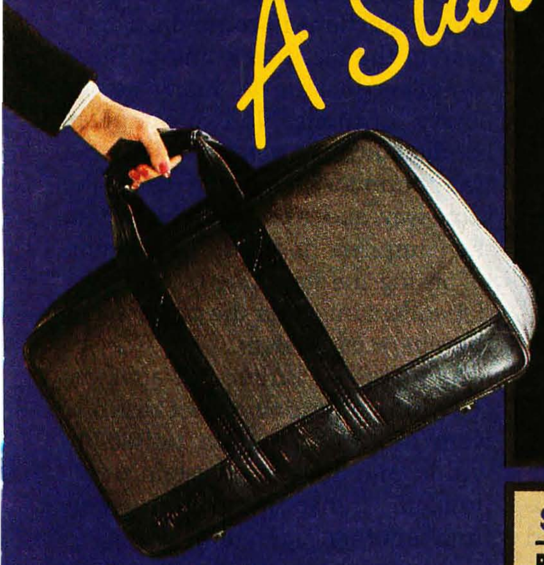

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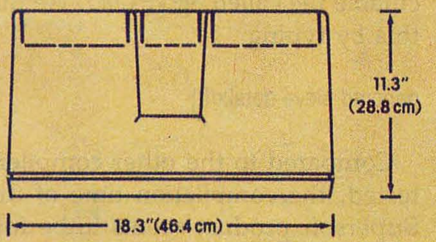

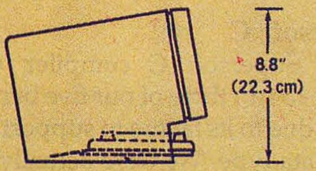

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only other one tested that supports overlays.

Though this overlay technique generates programs that will run more slowly than the RAM-resident code supported by the Digital Research compiler, it does have the advantage of conserving memory use, which can be especially important in a multiuser MP/M-86 system. Even this sacrifice in speed can be minimized if overlays are restricted to a program's seldom-used options, in which case, overlays would allow an application program lots of convenient extras that might otherwise have been eliminated due to lack of space.

We have maintained a polite silence concerning the documentation that comes with the other compilers. With Lattice, we have to say that the documentation is superb. Only DRI even comes close.

In general, the Lattice compiler is a sophisticated, high-performance package that appears to be well suited for development of major application programs. It is unfortunate that the CP/M-86 version of Lattice was released only recently, so we have not been able to use it in production work. The benchmarks, on the other hand, speak for themselves. Lattice is a real performer. Announced improvements are a debugging facility, support for register variables and for the 8087 math coprocessor, and an additional level of optimization for speed (this should be interesting, because Lattice already seems to be the fastest).

Supersoft C

The Supersoft C compiler was unable to run three of our five benchmarks due to its failure to support the long data type. We were actually relieved that Supersoft had this failing because the process of producing executable code through the Supersoft compiler is like pulling teeth.

The great problem with the Supersoft C compiler package is that it has neither a linker nor a library-search feature. This means that to compile a program easily, you must include all library files (either on the compiler command line or with an #include statement in the source file). This will ensure that all necessary library routines will be compiled with your code. It also ensures that all *unnecessary* library routines will be compiled with your code, thereby resulting in an enormous object file.

To create a smaller object file, you must cull the specific library functions required by your program from the Supersoft library source files, as well as extract the library functions called by those functions. You then use your favorite editor to patch all these together into a single file and include this new file when you compile your program.

In the two benchmarks we ran, we used the CRUNT2.C library module in toto and an editor to extract from the FORMATIO.C module the source code for printf. We then extracted the routines that printf called and included them all in a library we called printf.c. We compiled the sieve program with the following commands:

```
cc sieve.c crunt2.c printf.c
cod2cod sieve.cod
c2i86 sieve.u
```

This created assembly source code, which we assembled with the Digital Research assembler ASM86 using the following command:

```
asm86 sieve
```

This produced an object file of type .H86, which we fed to the CP/M-86 loader, GENCMD, to produce an executable file called SIEVE.CMD. We did this by typing

```
gencmd sieve data[xfff]
```

Compared to the other compilers tested, the compilation time of the Supersoft product seems to be forever. More precisely, it is 47 times longer than the DeSmet compiler. A saving grace of the Supersoft compiler is that it gives the complete source for its library—a feature shared only by the Computer Innovations compiler.

The Elusive Ideal of Portability

Though portability is one of the most prized characteristics of C, we were surprised at how difficult it was to find code that would run on all six of the compilers. Most surprising was that the five compilers we considered the most significant had only 14 library functions in common. This is despite the fact that some of these compilers include as many as 100 library functions. No two compilers handled direct movement of data that was bound for memory in exactly the same way, and, as might be expected, the compilers had little in common regarding the handling of functions dependent on either the processor or the operating system.

As we stated earlier, our attempts at writing a routine to test disk I/O were futile. If program portability within one operating system was a problem, transporting C programs from another operating system to CP/M promises to be especially thorny. For example, a severe incompatibility exists between CP/M and Unix. The exact length of a CP/M file is known only to within 128 bytes, whereas the length of a Unix file is known exactly (it has 1-byte "granularity"). This means that any C program written for Unix that relies on the operating system to provide the exact length of a file will be impossible to transport to a CP/M environment without a significant rewrite.

On a more upbeat note, we were startled not just by the large quantity, but the extremely high quality of C compilers already available for CP/M-86. By the time this article appears, four more compilers should be available from Aztec, Telecon, Whitesmiths, and Epsys. Sounds like C is here to stay.■

Jerry Houston is vice-president of marketing at Gifford Computer Systems (1922 Republic Ave., San Leandro, CA 94577). He was formerly head of the technical departments at Computer Marketing Associates, Morrow Designs, and Compupro.

Jim Brodrick, who holds a doctorate in biochemistry from the University of California at Berkeley, is on the software research and development staff at Gifford Computer Systems. He has five years of experience as a C programmer and has written a C compiler for CP/M-86.

Les Kent is manager of research and development at Gifford Computer Systems. He was formerly chief production programmer at Morrow Designs and is an authority on the Unix operating system.

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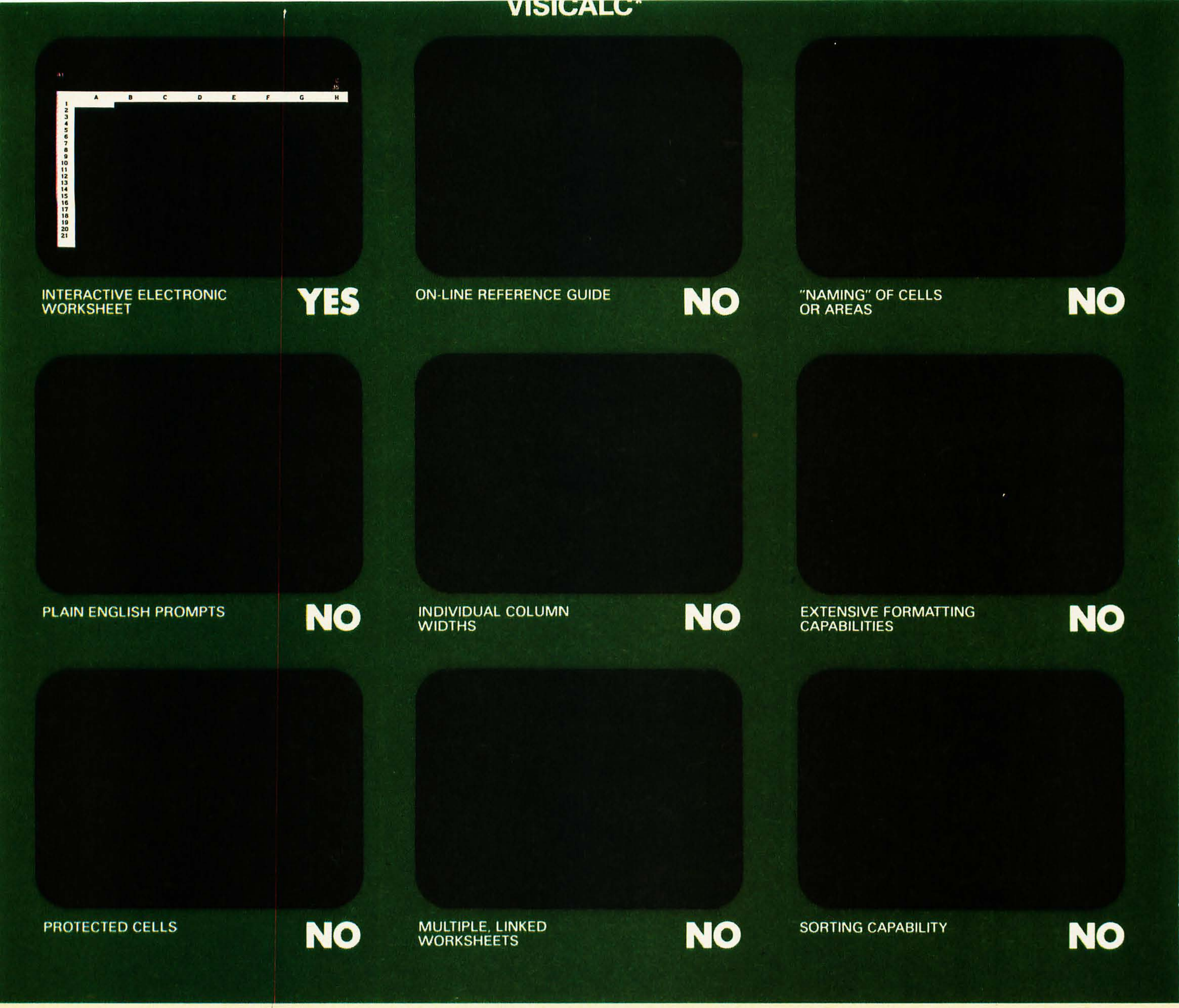

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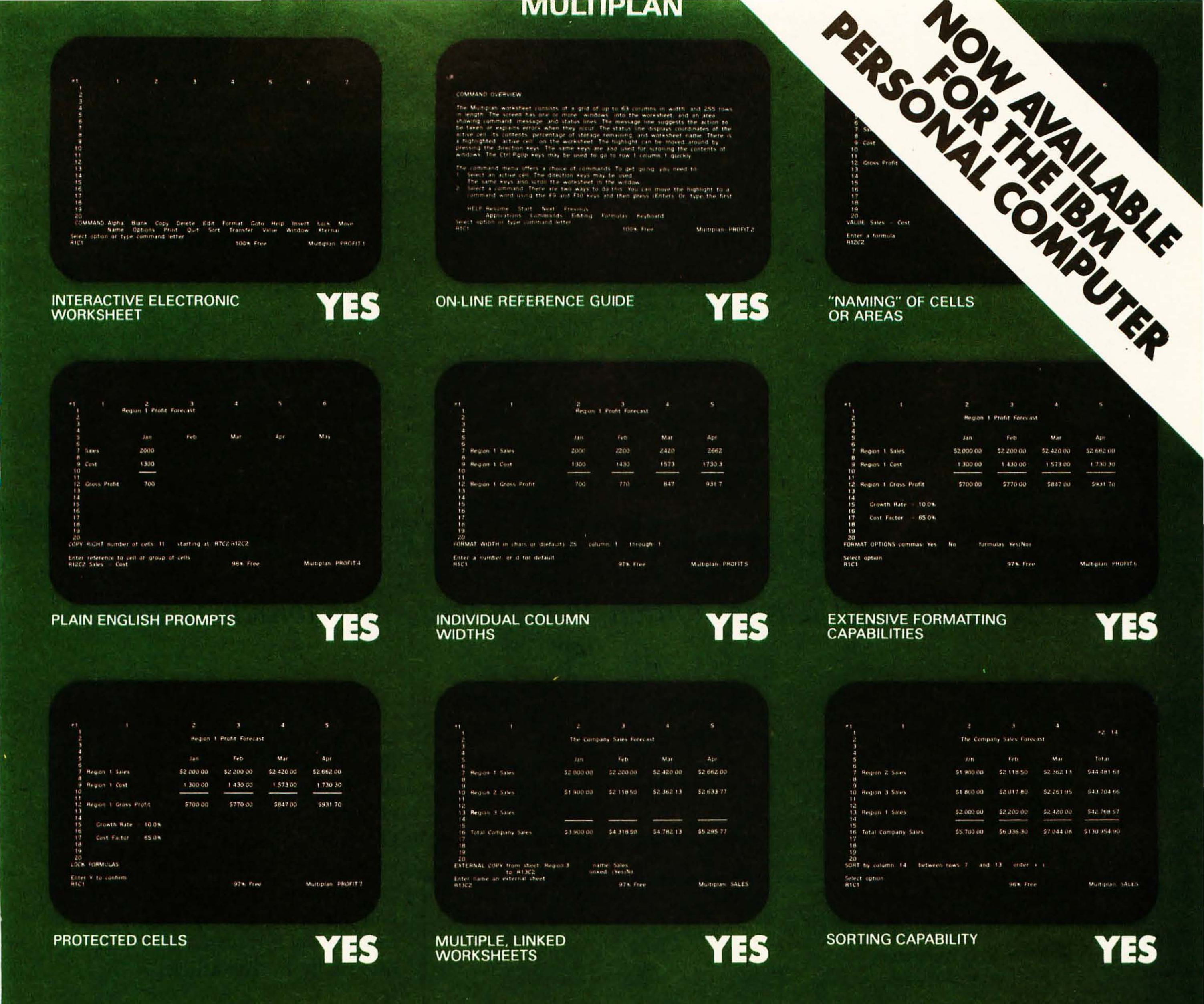

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Five C Compilers for CP/M-80

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by Christopher O. Kern

Choosing a C compiler is not a trivial task. That is clear to me after spending several weeks comparing C compilers for 8080-family microcomputers running under the CP/M-80 operating system. I found that there is considerable variation in the time required to compile programs, the speed with which compiled programs run, and the size of the executable machine code that is produced. The compilers I tested were Aztec C version 1.05G, BDS C version 1.5, C/80 C version 2.0, Telecon C version 2.7, and Whitesmiths C version 2.1 (see "At a Glance"). I have summarized the features of these compiler packages in table 1, and I'll discuss my impressions of them individually in this article.

	Aztec	BDS	C/80	Telecon	Whitesmiths
Kernighan and Ritchie complete	x				[6]
Kernighan and Ritchie standard library	x				
source for library	x	x	x	x	
source for run-time routines	x	x	x	x	
separately linkable modules	x	x	[4]		x
preprocessor arguments	x	x		x	x
intermediate assembler file	x		x	x	x
in-line assembly language	x		x	[5]	
I/O redirection	x	[2]	x	x	x
library manager	x	x			x
debugging aids		x	x		
floating-point arithmetic	x	[3]			x
M80-compatible code	[2]		[2]		
requires CP/M 2.0		x			
system size required (kilobytes)	56	40	48	48	60
disk space required (kilobytes) [1]	134	55	58	81	260
size of manual (pages)	86	185	35	16	>300 [7]
list price	$199	150	49.95	200	700

[1] Minimum for compiling and linking a program
[2] Optional
[3] No native floating point; supplies library functions to provide long and floating-point arithmetic
[4] With Microsoft M80/L80 relocating macroassembler (not supplied)
[5] Assembly-language source files can be combined with C source files at compile time
[6] Follows Unix version 6 rather than version 7 compiler
[7] Includes manual pages for several operating systems

Table 1: *Summary of the features of the C compilers.*

About C

The C programming language is a natural for 8-bit computers. C is considerably more powerful than assembler but still permits access to most of the host computer's basic machine operations. It is simple enough to be completely implemented for a computer with a limited instruction set and a relatively small main memory. It is potentially quite portable because it interfaces to the host computer through a standard input-output (I/O) library. And it's easy for amateurs like me to learn.

The Test Programs

I decided at the outset that there were at least four major tests I wanted to perform on each compiler. The first test was for efficiency in accessing

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automatic variables, which come into existence only when a particular function is entered. As soon as the function is exited, the variables are discarded. In other words, automatic variables exist while the function they belong to is actually executing. They are a problem on an 8-bit computer because of its shortage of registers and its limited addressing modes.

A good choice for this test was the Sieve of Eratosthenes program for generating prime numbers that Jim and Gary Gilbreath used in their article "Eratosthenes Revisited: Once More Through the Sieve" (see the January 1983 BYTE, page 283). It has quite a few variables, which are constantly being juggled among machine registers so that arithmetic and logical operations can be performed on them (see listing 1). To make the test as pure as possible would require moving the array of flags into the function proper, i.e., making the array an automatic variable instead of an external one.

The second test I wanted to perform was to measure the efficiency of each compiler in coding function (procedure) calls. Because good C style encourages the use of many small functions instead of a few large ones, I wanted to see how much overhead was associated with entering and leaving a function.

To do that, I wrote a program to compute a Fibonacci series recursively. The Fibonacci function, $F(x)$, is defined as:

$$F(x) = 1 \quad \text{for } x \le 2$$
$$F(x) = F(x-1) + F(x-2) \quad \text{for } x > 2$$

(see listing 2). Because only one variable is involved and relatively little processing is performed on it, the Fibonacci program is a good test of function overhead.

Many C programs read or write a file one character at a time. Because most operating systems won't let you do that, at least not efficiently, the standard library supplied with each of the C compilers includes several functions to perform buffered I/O (input/output).

Here is how it works: a file is read into a buffer in relatively large chunks. Then it is parceled out to the program byte by byte. In writing to a file, the process is reversed: the file is assembled in the buffer 1 byte at a time. When the buffer becomes full, it is "flushed"—written out to the disk in a single, relatively efficient operation.

My third test program simply copies its input to its output (see listing 3a). I knew that the results of this test would in large part reflect the size of the buffers used by each compiler. As a rule, the larger the buffer, the faster the program would run; but the results indicate that other factors are at work as well.

Finally, I wanted to see how each compiler package performed in handling strings. Strings in C are just arrays of characters, delimited by a single null or zero byte. Internally, each character is represented by an offset to a pointer variable. The variable points to the starting address of the string in the computer's memory.

Pointers are used quite a bit in C programming, much as they are in assembly programming, and in sharp contrast to languages like BASIC and Pascal, which can operate on strings directly. In C, several crucial library functions perform basic operations on strings, such as measuring or comparing them.

I used a program to sort lines of text alphabetically to test each compiler's string-handling ability. The only problem was how to read the test data into the program. To eliminate any variation among the packages in performing file I/O, I decided to have the program take its input from the console (see listing 4 on page 121).

But instead of typing in the lines by hand—which obviously would have injected an uncontrollable variable into the test procedure—I read them from a file using Microshell. Microshell is a replacement CP/M-80 command interpreter that allows the "redirection" of console input. In effect, the program thinks it is getting its input from the console when in fact it

Listing 1: *The prototype of the* primes *program, which was written in the version of C described by Kernighan and Ritchie; it generates primes using the Sieve of Eratosthenes method. The program's purpose is to test the compiler's efficiency in using automatic variables. This is the basic version of the program that was tried on all the compilers; some modifications were necessary to get it to run on each one.*

```
A>
A>type sievel.c
SIEVE1.C?

A>type b:sievel.c
#include "stdio.h"

#define  SIZE     8190   /* size of number array */
#define  FALSE       0
#define  TRUE        1

        char     flag[SIZE + 1];

main( )          /* compute primes using sieve of Eratosthenes */
{
        int      i, j, k, count, prime;

        printf("10 iterations: ");

        for (i = 1; i <= NTIMES; i++) {
                count = 0;
                for (j = 0; j <= SIZE; j++)
                        flag[j] = TRUE;
                for (j = 0; j <= SIZE; j++) {
                        if (flag[j] == TRUE ) {
                                prime = j + j + 3;
                                for (k = j + prime; k <= SIZE; k += prime)
                                        flag[k] = FALSE; /* discard multiples*/
                                count++;
                        }
                }
        }

        printf("%d primes.\n", count);
        exit(0);
}
```

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is getting it from a file. (See my review, "Microshell and Unica: Unix-style Enhancements for CP/M," December 1982 BYTE, page 206.) Because Microshell performed the file I/O, the time required to read the data was the same in all the tests.

All the prototype test programs were written to conform to the standard set out in *The C Programming Language*, by Brian W. Kernighan and Dennis M. Ritchie (Prentice-Hall, 1978). This is the "bible" of C programming and a fine tutorial introduction to programming in general. All the compilers tested cite it. As it turned out, only one—Aztec C—really followed it.

The Method

As each compiler arrived, I tried it out on each of the prototype test programs. Usually I had to make some changes to get the programs to compile. Only the Aztec compiler accepted all the prototype code without modification.

The copy program would not work with the BDS compiler because the file I/O functions in the BDS library are nonstandard (see listing 3b). Both the copy and sort programs had to be changed before they could be compiled with C/80 because the C/80 library does not include the common string comparison and measurement functions.

The Telecon compiler surprised me. It couldn't handle the addition of two constants in the subscript of an array declaration (e.g., array[SIZE + 1]) such as that used in the primes program. And the Whitesmiths compiler until recently came with its own idiosyncratic "standard" I/O library; as a consequence, all the programs needed minor changes (see listing 3c for an example). **[Editor's note:** *Whitesmiths has fixed this by offering an additional Unix-compatible I/O library that has all of the standard C functions. . . .* **B.R.]**

These initial tests and conversions gave me some experience with the compilers I was not familiar with. I had used BDS C and C/80 before, but I wanted a uniform environment for the actual timing tests. I made up a set of identical floppy disks, which

Text continued on page 122

Listing 2: *Prototype of the* fib *program, which uses recursion to compute a Fibonacci series. The recursion tests the compiler's handling of function calls.*

```
#include "stdio.h"

#define  NTIMES  10      /* number of times to compute Fibonacci value */
#define  NUMBER  24      /* biggest one we can compute within 16 bits */


main( )                  /* compute Fibonacci value */
{
        int      i;
        unsigned value, fib( );

        printf("%d iterations: ", NTIMES);

        for (i = 1; i <= NTIMES; i++)
                value = fib(NUMBER);

        printf("fibonacci(%d) = %u.\n", NUMBER, value);
        exit(0);
}


unsigned fib(x)          /* compute Fibonacci number recursively */
int x;
{
        if (x > 2)
                return (fib(x - 1) + fib(x - 2));
        else
                return (1);
}
```

Listing 3: *The* copy *program. This tests the compiler's buffered I/O capabilities. Listing 3a is the prototype; listing 3b and listing 3c are the BDS and Whitesmiths versions, respectively. Note that the BDS file-input and file-output functions require the programmer explicitly to look for and end a file with the CP/M-80 end-of-file character (represented by CPMEOF). In the Whitesmiths version, note the differences from the prototype in the* cpmstr, fopen, fcreate, putc, *and* putfmt *functions. The constant values in uppercase are all defined in the standard header file* std.h.

(3a)

```
#include "stdio.h"


main(argc, argv)         /* copy file a byte at a time */
int argc;
char *argv[];
{
        int     c;
        FILE    *infile, *outfile;

        if (argc < 3)
                errexit("Usage: copy oldfile newfile", NULL);
        if (strcmp(argv[1], argv[2]) == 0)
                errexit("File names must be different", NULL);
        if ((infile = fopen(argv[1], "r")) == NULL)
                errexit("Can't open", argv[1]);
        if ((outfile = fopen(argv[2], "w")) == NULL)
                errexit("Can't create", argv[2]);

        printf("File %s ", argv[1]);

        while ((c = getc(infile)) != EOF)
                putc(c, outfile);

        fclose(infile);
        fclose(outfile);

        printf("copied to %s.\n", argv[2]);
        exit(0);
}


errexit(s1, s2)          /* print error message and die */
char *s1, *s2;
{
        printf(s2 == NULL ? "%s\n" : "%s %s\n", s1, s2);
        exit(-1);
}
```

Listing 3 continued on page 116

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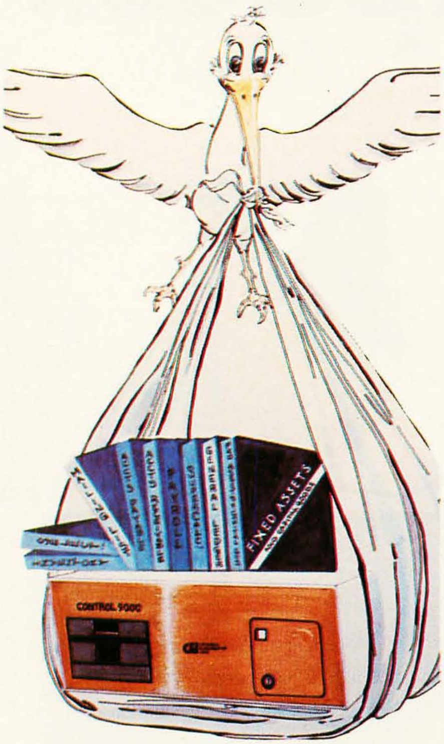

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Listing 3 continued:

(3b)

```
#include "bdscio.h"


main(argc, argv)        /* copy file a byte at a time */
int argc;               /* uses BDS library functions */
char *argv[];
{
        char    c;
        FILE    infile, outfile;

        if (argc < 3)
                errexit("Usage: copy oldfile newfile", NULL);
        if (strcmp(argv[1], argv[2]) == 0)
                errexit("File names must be different", NULL);
        if (fopen(argv[1], &infile) == ERROR)
                errexit("Can't open", argv[1]);
        if (fcreat(argv[2], &outfile) == ERROR)
                errexit("Can't create", argv[2]);

        printf("File %s ", argv[1]);

        do {
                putc(c = getc(&infile), &outfile);
        } while (c != CPMEOF);

        fclose(&infile);
        fclose(&outfile);

        printf("copied to %s.\n", argv[2]);
        exit(0);
}


errexit(s1, s2)         /* print error message and die */
char *s1, *s2;
{
        printf(s2 == NULL ? "%s\n" : "%s %s\n", s1, s2);
        exit(-1);
}
```

(3c)

```
#include "std.h"


main(argc, argv)        /* copy a file a byte at a time */
int argc;               /* uses Whitesmiths library functions */
char *argv[];
{
        int     c;
        FIO     infile, outfile;

        if (argc < 3)
                errexit("Usage: copy oldfile newfile", NULL);
        if (cmpstr(argv[1], argv[2]) == YES)
                errexit("File names must be different", NULL);
        if (fopen(&infile, argv[1], READ) == NULL)
                errexit("Can't open", argv[1]);
        if (fcreate(&outfile, argv[2], BWRITE) == NULL)
                errexit("Can't create", argv[2]);

        putfmt("File %p ", argv[1]);

        while ((c = getc(&infile)) != EOF)
                putc(&outfile, c);

        fclose(&infile);
        fclose(&outfile);

        putfmt("copied to %p.\n", argv[2]);
        exit(0);
}


errexit(s1, s2)         /* print error message and die */
char *s1, *s2;
{
        putfmt(s2 == NULL ? "%p\n" : "%p %p\n", s1, s2);
        exit(-1);
}
```

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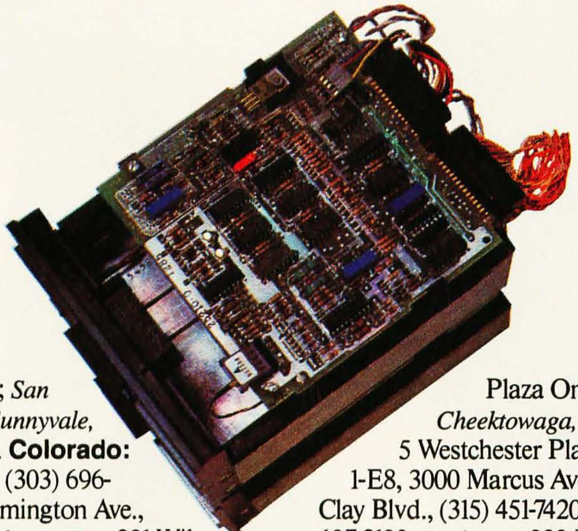

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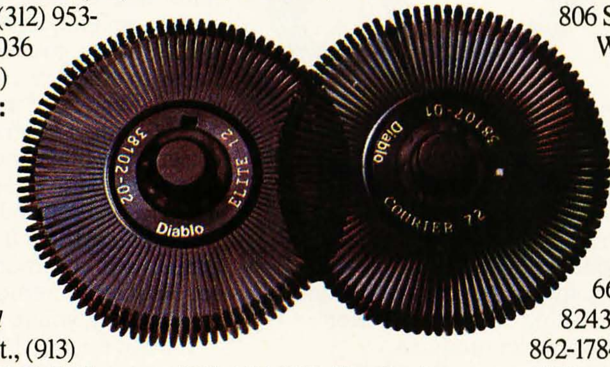

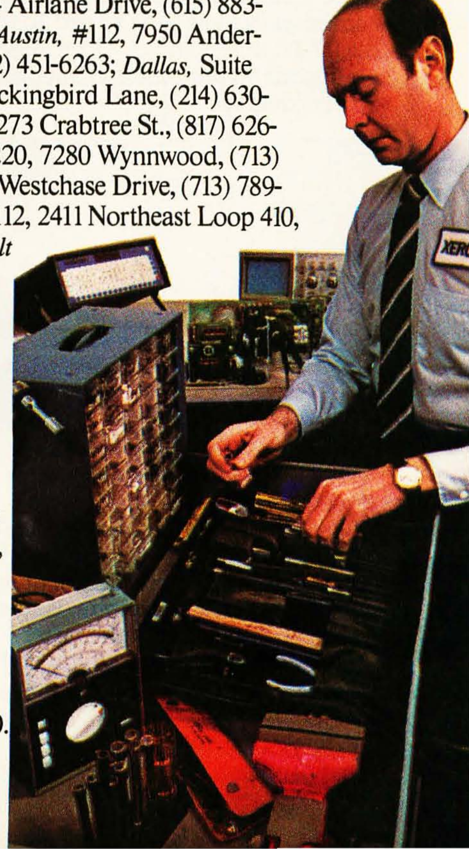

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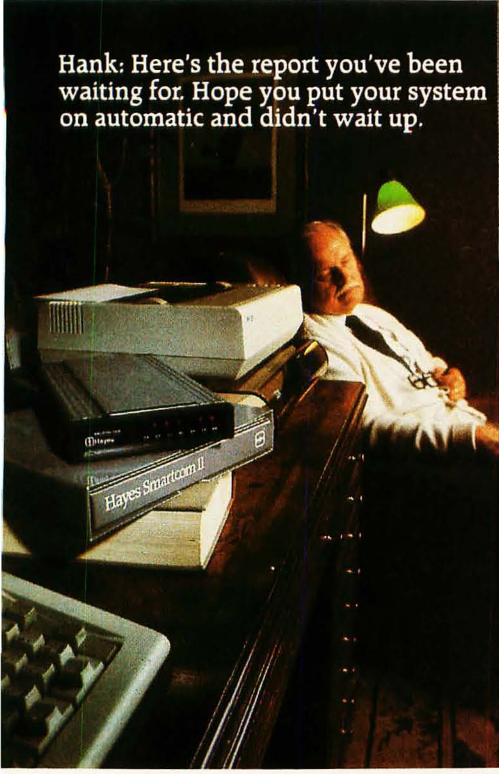

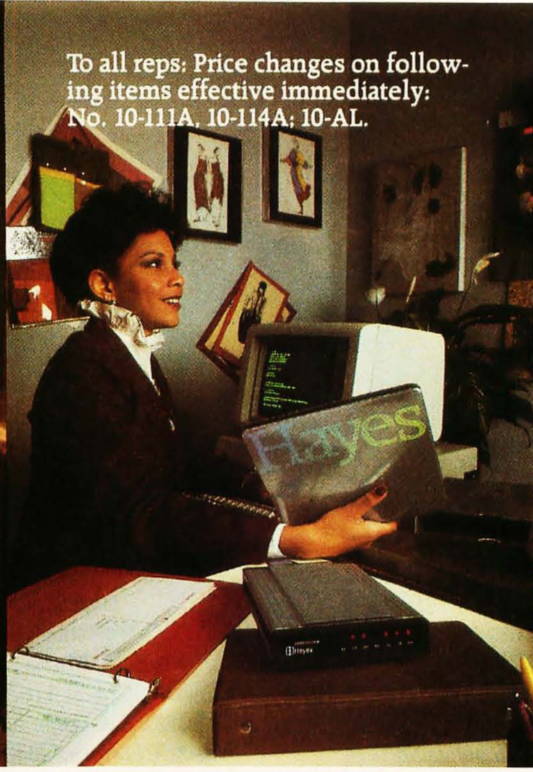

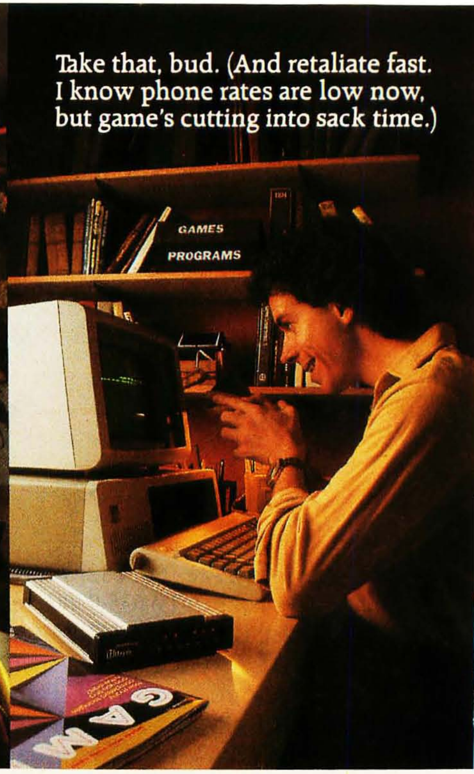

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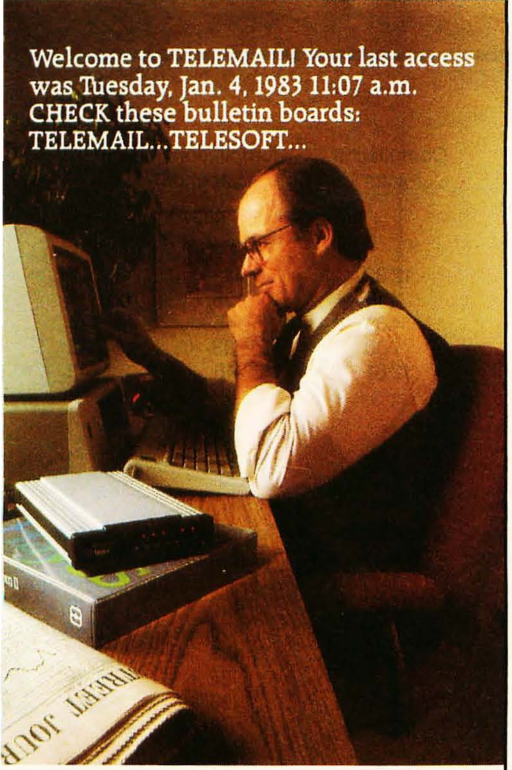

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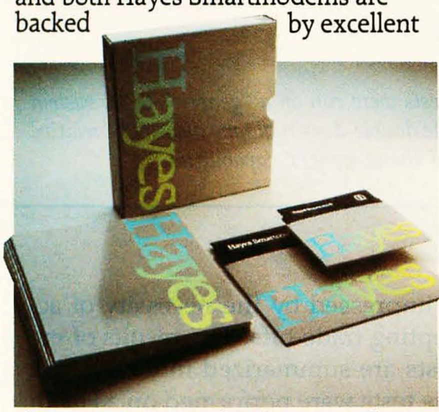

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Listing 4: *The prototype* sort *program tests each compiler's handling of pointers.*

```
quick( lo, hi, base )     /* quicksort */
int lo, hi;
char *base[];
{
        int     i, j;
        char    *pivot, *temp;

        if (lo < hi) {
                for (i = lo, j = hi, pivot = base[hi]; i < j; ) {
                        while (i < j && strcmp(base[i], pivot) <= 0)
                                i++;
                        while (j > i && strcmp(base[j], pivot) >= 0)
                                j--;
                        if (i < j) {
                                temp = base[i];
                                base[i] = base[j];
                                base[j] = temp;
                        }
                }
                temp = base[i];
                base[i] = base[hi];
                base[hi] = temp;
                quick( lo, i - 1, base );
                quick( i + 1, hi, base );
        }
}


getln(s, n)             /* get a line of up to n characters into s */
char s[];
int n;
{
        int     c, i;

        for (i = 0; n > 0; n--, i++)
                if ((c = getchar( )) == EOF || c == '\n')
                        break;
                else
                        s[i] = c;

        s[i] = '\0';
        return (i);
}
#include "stdio.h"


#define  MAX      1001   /* maximum number of entries */
#define  MAXLINE  135    /* longest line expected */
#define  NTIMES    10    /* number of times to sort entries */


main( )                  /* sort lines in memory */
{
        int     i, j, n, length;
        char    buf[MAXLINE], *sort[MAX], *unsorted[MAX], *alloc( );

        for (n = 0; n < MAX; n++)
                if ((length = getln(buf, MAXLINE)) == 0) {
                        n--;
                        break;
                }
                else if ((unsorted[n] = alloc(length + 1)) == NULL) {
                        printf( "Sort: not enough room\n");
                        exit(-1);
                }
                else
                        strcpy( unsorted[n], buf);

        printf( "%d iterations: ", NTIMES);

        for (i = 1; i <= NTIMES; i++) {
                for (j = 0; j <= n; j++)
                        sort[j] = unsorted[j];
                quick(0, n, sort);
        }

        printf( "%d entries.\n", n + 1);
        exit(0);
}
```

Text continued from page 114:
contained various utilities as well as test data for the copy and sort programs. This minimized variations in disk-access time during testing.

The test file for copy was 1000 lines of text—80K bytes in all. To get test data for the sort program, I created a file containing the first 1000 words of an earlier article I had written for BYTE. The words were placed in the file in the order they appeared in the article, each on a separate line. Finally, I reserved a disk for each compiler and copied onto it only those programs and files that were necessary for compilation of the test programs.

I compiled the test programs using a CP/M-80 SUBMIT script, which enabled me to automate the various commands that made up each compilation. Once again, my goal was uniformity. By letting the SUBMIT file control compilation, I eliminated any variation that might have been caused by changes in the speed of typing in commands by hand.

All timing measurements were made with a Hayes serial clock that was connected to the computer. The SUBMIT script used to compile the programs read the clock at the beginning and end of each compilation. Similarly, I used a multiple-command line under Microshell to read the time just before and after each program was executed. I performed each of the tests several times with each of the compilers. The variation in time—for either compilation or execution—never exceeded 1 second.

The Telecon compiler partially defeated my attempts at standardization. It takes two steps to invoke any Telecon program, including the compiler. The extra step is required by the Telecon "shell," a command interpreter that is made a part of every compiled program.

When you type the name of a program compiled under Telecon, CP/M-80 loads the program into memory, but instead of executing immediately, the program waits until you enter optional parameters to the shell. Even if the program doesn't require any optional parameters, you still have to enter an extra carriage return before it starts to run.

Program: primes (see listing 1)

Compiler	Execution Factor	Execution Time (Seconds)*	Compilation Factor	Compilation Time (Seconds)*	Bytes
Whitesmiths	1.00	60	12.82	423	15744
C/80	1.05	63	4.18	138	3584
Aztec	1.30	78	4.39	145	9168
BDS	1.43	86	1.00	33	3812
Telecon	1.45	87	12.61	416	5443

Program: fib (see listing 2)

Compiler	Execution Factor	Execution Time (Seconds)	Compilation Factor	Compilation Time (Seconds)	Bytes
Whitesmiths	1.00	153	12.59	403	15616
Telecon	1.10	168	12.59	403	5245
C/80	1.12	171	4.16	133	3217
BDS	1.32	202	1.00	32	6159
Aztec	1.55	237	4.16	133	8974

Program: copy (see listings 3a-3c)

Compiler	Execution Factor	Execution Time (Seconds)	Compilation Factor	Compilation Time (Seconds)	Bytes
BDS	1.00	144	1.00	41	6159
Aztec	1.07	154	4.05	166	11482
C/80	2.47	356	3.56	146	3840
Whitesmiths	2.86	412	11.80	484	18560
Telecon	3.85	554	10.29	422	5574

Table 2: *Results of the benchmark tests. The tests were run on a "generic" S-100 system using a Z80 processor at 4 MHz, with 484K-byte double-density floppy disks. The relative execution speeds provide a valid comparison of the compilers' capabilities.*

I used a stopwatch to time the first part of the Telecon compilations (the compiler proper) and my usual method with the Hayes serial clock for the rest (assembly and loading). The execution times for the Telecon programs were obtained in the same way as those for the programs created with the other compilers, but I had to enter the command-line arguments or the extra carriage returns by hand. Strictly speaking, the Telecon timings are not directly comparable to those of the other compilers.

The Results

I started this experiment hoping to find the best of the 8080 C compilers, if not a perfect one. I came away from it impressed by the necessity of accepting trade-offs. The results of my tests are summarized in table 2. All the tests were performed on a Heath H8, using a Heath H47 disk drive with approximately 1.2-megabyte capacity and a Z80 processor running at 2 MHz. (Note that most Z80-based machines run at twice that speed, so for the processor-intensive programs—primes, fib, and sort—my tests took roughly twice as long as they would have on a computer with a 4-MHz clock.)

I must emphasize the relative nature of the test results: A program that takes 1 second on this computer system does not necessarily require 1 second on systems with different processor speeds or those with disk

Program: sort (see listing 4)

Compiler	Execution Factor	Execution Time (Seconds)	Compilation Factor	Compilation Time (Seconds)	Bytes
Aztec	1.00	129	5.36	209	11796
Whitesmiths	1.36	175	14.67	572	18304
C/80	1.94	250	4.28	167	4259
BDS	2.31	298	1.00	39	5631
Telecon	**				

** Could not compile program

String-Length Test (see listing 5a)

Compiler	Execution Factor	Execution Time (Seconds)*
Whitesmiths	1.00	138
Aztec	1.25	172
BDS	1.43	197
Telecon	2.04	282
C/80	2.59	357

With Register Variable (see listing 5b)

Compiler	Execution Factor	Execution Time (Seconds)	Improvement
Aztec	1.00	72	58%
Whitesmiths	1.22	88	36%
C/80	2.65	191	46%
BDS	2.74	197	0
Telecon	3.92	282	0

drives having different access times from the drives used here. It is more useful to compare the compilation factors or execution factors listed for each compiler.

These factors are a measure of how each compiler performed with respect to the others. The compiler that produced the fastest time in each category has a factor of 1.00. All the other scores are proportionally higher. So if compiler *x* produced a program that took half again as long to run as the leader, its execution factor would be 1.50.

Whitesmiths C produced the fastest code in two of the four test programs, primes and fib. Aztec C was substantially faster than the others in the sort program. Aztec C and BDS C, with their 1024-byte buffers, were the fastest in copying files. An interesting result was that C/80, which uses only a 256-byte buffer—half the size used by Whitesmiths C—beat Whitesmiths C in the copy test.

You can compile a program with the BDS compiler much more rapidly than with any of the others. It compiled and linked the test programs in about one-quarter of the time required by the next-fastest compiler. The C/80 programs were always the shortest. And, as I have noted, Aztec was the only compiler that accepted all the test programs without change. In the 8-bit world, at least, the Kernighan and Ritchie standard is something less than standard.

While I had to introduce quite a few minor variations to get the test programs to work with each of the compilers, they all turned out to be fairly similar to their prototypes. That's what I wanted. It would have been possible to speed up some of the programs or to squeeze a few bytes out of them by using programming tricks to optimize the code for each particular compiler; but then the basis for comparison would be lost.

One "trick" is common to several of the compilers, however: the use of register variables. A register variable is kept in a machine register whenever possible. That means it can be accessed or changed somewhat more quickly than other automatic variables.

Of course, only a limited number of registers are available in any central processor. That is particularly true of the 8-bit processors for which these compilers produce their code. Excess register declarations are simply ignored.

I wanted to see how useful register variables might be with each of the compilers. To find out, I wrote a program that repetitively calculated the length of a string. I tested the string-length function with and without a register variable (see listings 5a and 5b; the results appear in table 2).

Note that the BDS and Telecon compilers do not appear to support register variables in any form. C/80, on the other hand, allows an unlimited number. They are obviously not stored in machine registers, but rather in absolute memory locations, presumably where they can be accessed by the 8080's LHLD and SHLD load instructions.

The Aztec C Compiler

The Aztec compiler is a single program that produces an assembly-language output file. This is then assembled with a supplied relocating assembler and linked with the standard library routines, along with any other precompiled modules the user may have created, using a linking loader that also comes with the package. A separate library utility is provided to manipulate compiled program modules, such as the standard

Listing 5: *Two versions of this string-measuring program test the speed of the compilers' code with (5a) and without (5b) register variables.*

(5a)

```
#include "stdio.h"

#define NTIMES 25000
#define S "Now is the time for all good men to come to the aid of the parity."


main( )         /* repeatedly measure length of string */
{
        int i;

        for (i = 1; i <= NTIMES; i++)
                strlng(S);

        exit(0);
}


strlng(s)       /* return length of string */
char *s;
{
        char *p;

        for (p = s; *s != '\0'; s++)
                ;
        return (s - p);
}
```

(5b)

```
#include "stdio.h"

#define NTIMES 25000
#define S "Now is the time for all good men to come to the aid of the parity."


main( )         /* repeatedly measure length of string, register version */
{
        int i;

        for (i = 1; i <= NTIMES; i++)
                strlng(S);

        exit(0);
}


strlng(s)       /* return length of string */
register char *s;
{
        char *p;

        for (p = s; *s != '\0'; s++)
                ;
        return (s - p);
}
```

I/O library. The compiler can also generate code for the Microsoft M80 macroassembler and L80 linker. A second library of functions in Microsoft relocatable object format is supplied with the package.

A separate compiler produces Z80 code. I tried it out on the test programs used for this review. The code it generated was not significantly faster and only slightly tighter than that produced by the 8080 compiler. (The test results reflect the standard 8080 compiler.)

The Aztec compiler meets the full Kernighan and Ritchie standard. Actually, Aztec does not support bit fields—a redundant feature of the language—but it usually should be possible to move C source code from a Unix system to a CP/M-80 system and compile it without change.

The Aztec compiler was not the quickest of the lot. I didn't find it particularly easy to use. It did not generate the fastest code, nor the shortest. But then, it did not perform badly in any of these areas either. In other words, it is a solid, professional piece of software that—not incidentally—can compile standard C source files.

One of the few features that did bother me was a dynamic storage-allocation function in the library that is nonstandard. A standard one is included with the package, but I had to add it to the library myself.

I found the library manager, by the way, to be serviceable but rather awkward. It allows the replacement only of separately compiled "modules," rather than individual functions, which would be more flexible. And the manual section on the librarian is written in complex, breathless prose that I found difficult to follow.

The link phase of the Aztec compilation process is the only one that I found annoyingly slow. The compiler and supplied assembler move along quite nicely, and then the whole process turns sluggish at link time. It is necessary to look up error diagnostics in a table. That's a nuisance. It would be much easier if the diagnostics were written directly to the console.

I found one minor bug. The compiler would not accept an initialization in the form:

```
char *p = "literal string"
```

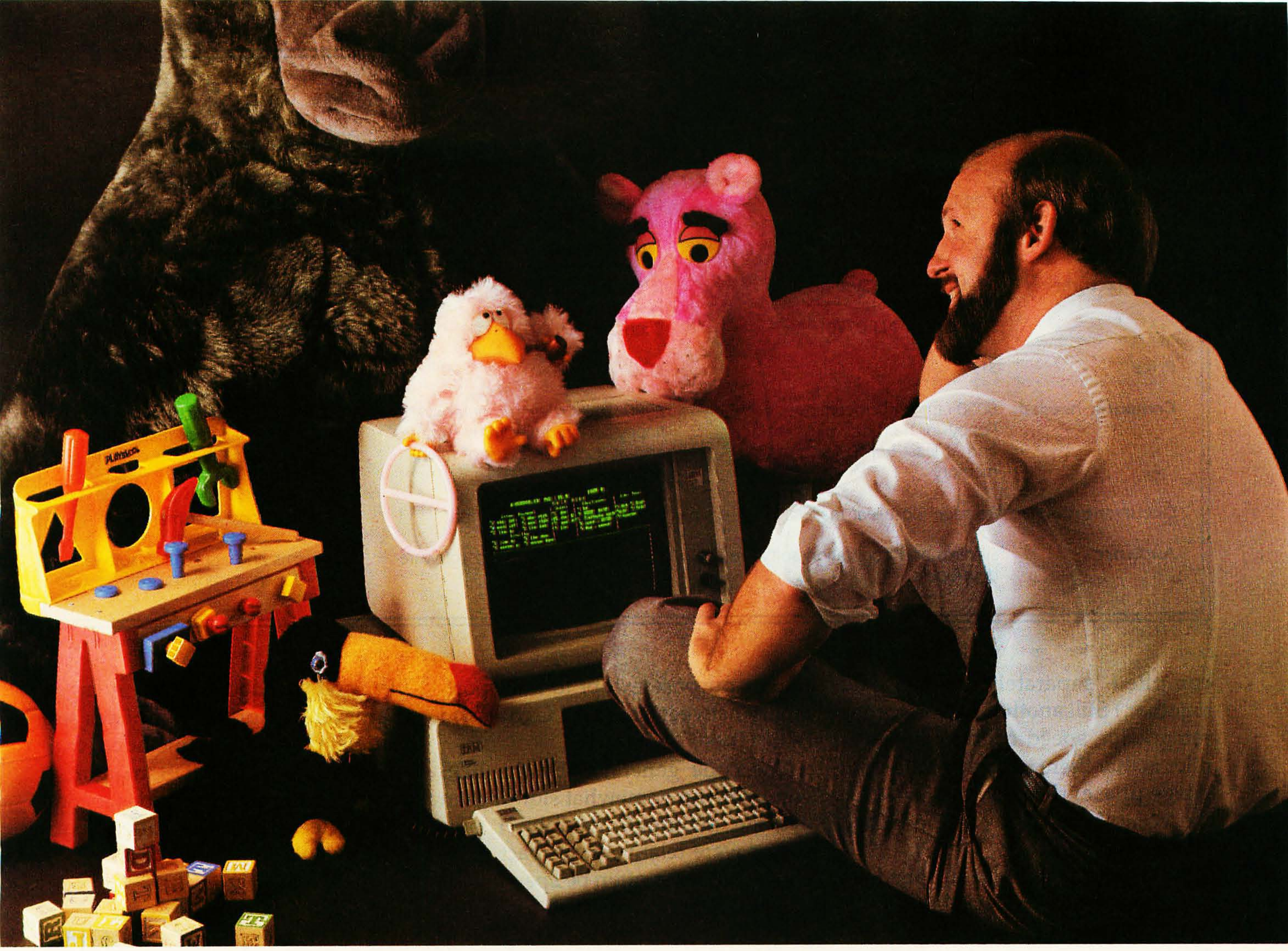
which is a common C idiom.

The Aztec manual is quite usable, but it lacks, and needs, an index.

The BDS C Compiler

The BDS C compiler is composed of two programs. One handles the standard C preprocessor functions and parses the source code. The second program generates machine code in a relocatable format. During compilation, the first program invokes the second automatically without creating any intermediate object files, which is one reason why the BDS compiler works so quickly.

Another reason is that the compiler reads the entire source program into the computer's main memory instead of passing it through a "window," or small block of memory. (This does not impose a limit on final program size because various modules can be



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At a Glance

Name	Aztec C Compiler	BDS C Compiler	C/80 C Compiler
Type	C compiler and utilities for CP/M-80	C compiler and utilities for CP/M-80	C compiler and utilities for CP/M-80
Version	1.05G	1.5	2.0
Manufacturer	Manx Software Systems POB 55 Shrewsbury, NJ 07701	B. D. Software POB 9 Brighton, MA 02135	The Software Toolworks 14478 Glorietta Dr. Sherman Oaks, CA 91423
Price	$199	$150	$49.95
Computer needed	8080-family microcomputer with floppy- or hard-disk mass storage and at least 56K bytes of main memory	8080-family microcomputer with floppy- or hard-disk mass storage and at least 40K bytes of main memory	8080-family microcomputer with floppy- or hard-disk mass storage and at least 48K bytes of main memory
Documentation	86-page loose-leaf manual	185-page loose-leaf manual	35-page loose-leaf manual
Audience	Systems and application software developers	Systems and application software developers, hobbyists	Systems and application software developers, hobbyists

compiled separately and linked together.) Still another reason for the remarkable speed of the BDS compiler is that there is no assembly-language phase: the code produced by the compiler is ready to be linked with the BDS linker.

A library utility is supplied to manipulate the relocatable object modules produced by the compiler. These are not compatible with the commonly used Microsoft relocatable format, and the BDS compiler doesn't have an option for generating Microsoft-format code. A symbolic debugging program is included with the BDS package sold by some distributors. If it is not included, it is available from a users group at a low cost.

The BDS compiler makes no claim to accepting Kernighan and Ritchie standard code. There are a number of variations from the standard that are well documented in the manual. These are mostly restrictions of one kind or another. So BDS code, per se, should normally compile under Unix.

Unfortunately, the buffered file I/O functions supplied with the BDS library are not standard. In some cases, they appear to be designed for greater efficiency or ease of implementation under CP/M-80. In other cases, the changes serve no apparent purpose except to limit portability between standard C code and BDS C.

The code generated by the BDS compiler was somewhat slower than average, although the object programs were relatively compact. BDS C programs can often be speeded up considerably by intelligent use of the preprocessor and by recoding some of the library functions into assembler. I know of at least one package of BDS C assembly-language functions that is available from a number of CP/M computerized bulletin-board systems around the country.

A considerable amount of other BDS C source code exists in the public domain—everything from games to quite sophisticated system utilities—and there is a national users group to help distribute it. This stockpile of public-domain software exists because BDS C was the first C compiler to become available for CP/M-80.

What distinguishes the BDS compiler, aside from the fact that it has been on the market longer than the others, is its ease of use. The entire package is a programmer's delight. It's not just their speed that sets the programs in this package apart. They are clean and comfortable and intuitive. The source code for the library and run-time routines is complete and well documented. A larger-than-average number of utilities and sample programs is included with the package. The BDS manual is lucidly written and includes a good deal of technical information about the generated code.

The C/80 C Compiler

The C/80 compiler is a single program that produces assembly-language code. The compiler output is not compatible with CP/M-80's ASM assembler; but an absolute assembler that produces executable machine code (not relocatable) comes with the package. Standard library routines are supplied in assembly language and are automatically included in every C/80 assembly. C/80 has an option to generate assembly-language code in Microsoft format, and a second library is supplied as a Microsoft-compatible, relocatable object file.

The C/80 compiler was born as a revision of the public-domain C compiler that was published by Ron Cain in *Dr. Dobb's Journal* back in May 1980 ("A Small C Compiler for the 8080's"). C/80 has grown far beyond its public-domain origins, however, and now supports a sizable subset of the Kernighan and Ritchie language. Like the BDS C compiler, C/80 is not a complete implementation. The I/O library in particular leaves something

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At a Glance

Name	Telecon C Compiler	Whitesmiths C Compiler
Type	C compiler and utilities for CP/M-80	C compiler and utilities for CP/M-80
Version	2.7	2.1
Manufacturer	Telecon Systems 1155 Meridian Ave., Suite 218 San Jose, CA 95125	Whitesmiths Ltd. 97 Lowell Rd. Concord, MA 01742
Price	$200	$750
Computer needed	8080-family microcomputer with floppy- or hard-disk mass storage and at least 48K bytes of main memory	8080-family microcomputer with floppy- or hard-disk mass storage and at least 60K bytes of main memory
Documentation	16-page loose-leaf manual	loose-leaf manual of more than 300 pages
Audience	Hobbyists	Systems and application software developers

to be desired. But given the $50 sales price, you would have to be crazy to complain.

Its limitations notwithstanding, C/80 is not a toy compiler. The code it generated for the test programs was reasonably fast and the most compact produced by any of the compilers that I tested. C/80 is obviously capable of doing serious production work. Walt Bilofsky's Software Toolworks, which sells C/80, also markets several products that were compiled with it.

C/80 writes object files in 256-byte chunks, so there was sometimes a discrepancy between the size of the object code as reported by the compiler and the number of 128-byte CP/M-80 sectors that were actually written to disk. (My statistics reflect the latter.)

The C/80 package includes a very valuable development tool: a profiler, a program to measure which parts of the code a program spends the most time executing. Unfortunately, it is of limited utility to those without Heath/Zenith computers because it uses a clock counter maintained by the Heath system software. A trace program is also included. It provides a list of each function call and return in the executing object program. The C/80 manual is short but well organized and well written.

The Telecon C Compiler

The Telecon C compiler, also a single program, produces code for the standard CP/M-80 absolute assembler, ASM. Library routines are incorporated into the compiler output from an assembly-language file that is supplied with the package. The manual states that the compiler is capable of producing code for a relocating assembler but gives no hint about the format or what additional programs are required to assemble it. The compiler produced serviceable code that ran a bit slower than average but was relatively short.

The Telecon library is nonstandard and incomplete. There is no dynamic storage-allocation function, for example, so I could not compile the sort program. As noted earlier, I found one bug: the compiler won't accept array subscripts that involve the addition of constants.

The Telecon shell, a command interpreter that is included in every compiled program, makes this compiler rather different from the rest. Telecon programs do not execute in the normal manner. After you invoke them, you are required to type in op-

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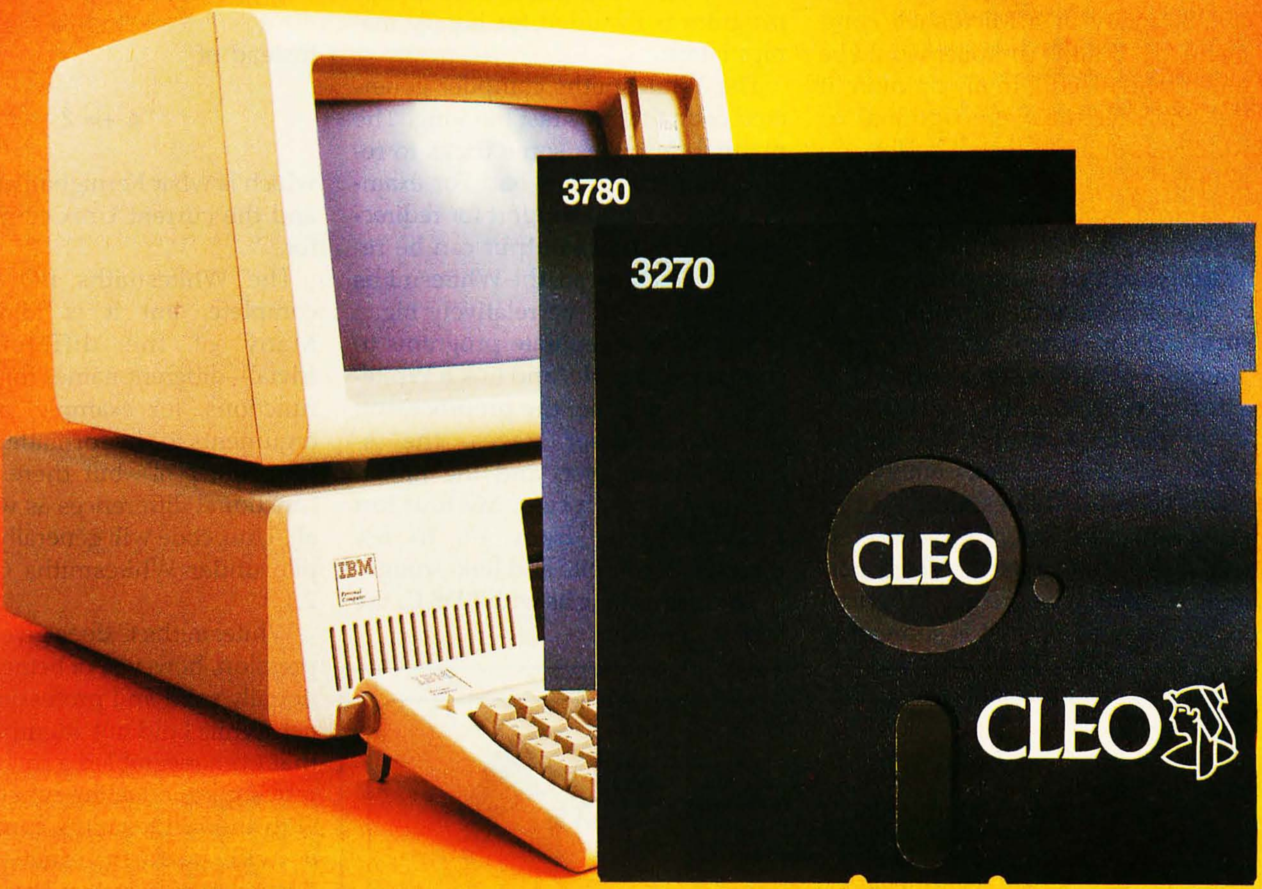

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tional arguments that would normally be placed on the CP/M-80 command line. Even if the program doesn't require any arguments, it still needs a carriage return before it starts to run.

It is possible to work around this to some extent by using the CP/M-80 XSUB facility or a Microshell command file. But the compiler would be much more useful, in my opinion, if the shell feature were optional or were left out altogether. The Telecon manual is poorly written, badly organized, and incomplete.

Whitesmiths C Compiler

The Whitesmiths C compiler is supplied as three separate programs—a preprocessor, a parser, and a code generator—each of which produces intermediate files. The output of the code generator is assembly-language code for Whitesmiths proprietary A-Natural assembler, an interesting program in itself, which permits assembly-language programming in a notation that is somewhat more intuitive and high level than standard assembly-language mnemonics and syntax.

A linker is supplied to combine the output of the assembler with the standard library. The relocatable output of the Whitesmiths assembler is not Microsoft-compatible. A separate program is included for library manipulation.

The Whitesmiths compiler generated code that was fast but long. The manual describes some tricks to reduce the size somewhat. For example, the run-time support for redirection of input and output can be removed. But even so, the Whitesmiths programs would be relatively big.

It takes five separate programs to compile, assemble, and link a Whitesmiths source file: the preprocessor, the two-compiler stages, the A-Natural assembler, and the linker. That is a slow process. My four test programs took from $4\frac{3}{4}$ to $6\frac{3}{4}$ minutes to compile and link—roughly 12 times as long as with BDS C, the fastest compiler.

While Whitesmiths C is a complete C implementation, it does not meet the Kernighan and Ritchie standard. The assignment operators follow the Unix version 6 compiler. That is, to increase *n* by 2, you use:

```
n =+ 2
```

instead of

```
n += 2
```

which is what Kernighan and Ritchie and the current Unix compilers call for.

The Whitesmiths I/O library is complete, but it is idiosyncratic. Many of the differences are trivial—different names for the string functions, for example, or for the arguments to the formatted printing function, printf—but there are some functional differences as well. All in all, Unix code will generally not compile under Whitesmiths C, version 2.1.

Whitesmiths C does give every impression, however, of being an exceptionally solid and professional product. While I did not attempt anything that even resembled a full validation test, I got the feeling when working with the Whitesmiths compiler that it will perform exactly as the documentation states. The documentation is a bit hard to use—one of the features that was modeled quite literally after Unix—but it is detailed and complete. Alas, it has no index.

The Envelope, Please

I had hoped to find one C compiler that was clearly the best of the lot. I didn't, but I know now what I am looking for. It should adhere to the Kernighan and Ritchie standard as closely as Aztec C, perform compilations as rapidly and have as clean an implementation as BDS C, be as dependable as Whitesmiths C, and be priced like C/80. Any takers?■

Chris Kern (Apartment 839, 201 I St., SW, Washington, DC 20024) is a journalist and computer hobbyist. He wrote BYTE's first review of a C language translator, "A User's Look at tiny-c," which appeared in the December 1979 issue, page 196.

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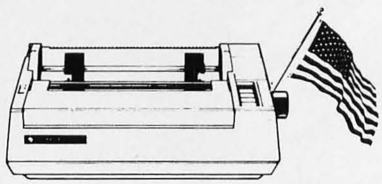

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Nine C Compilers for the IBM PC

Several versions of C are available for the IBM PC and the MS-DOS operating system—one of the most lucrative software markets for applications written in C

by Ralph A. Phraner

The IBM Personal Computer, a popular software-development vehicle for Intel's 8086 family of processors, is blessed with a profusion of peripherals. This environment has encouraged a dozen C language compilers so far, and several more will soon be added to the list.

After first outlining some general differences in compiler implementation, we'll take a look at nine compilers: c-systems C, Caprock small-c, Computer Innovations C86, DeSmet C, Intellect Associates C88, Lattice C (Microsoft C), Quantum C, Supersoft C, and Telecon C. One comes bundled with its own operating system, four run only under PC-DOS (the IBM PC version of Microsoft's MS-DOS), and the four remaining are available for either PC-DOS or the CP/M-86 operating system.

About C

Why all this interest in a low-level systems-programming language? The president of a commercial systems software house recently said that C has only two real advantages over other worthy programming languages: *it* is the only one he could get competent assembly-language programmers to use without significant backsliding in effort and enthusiasm and the only one that does not need to be extended to be useful. The latter point explains why, while subsets abound, there are virtually no nonstandard C supersets (a weakness in Pascal and FORTH) and thus no intentionally variant implementations.

C is a language of concise, consistent, pragmatic structure; its specification is widely available in a book that, in addition to providing a formal definition for the language, also includes many small teaching programs. Implementers are more likely to adhere to the standard because adherence is easy to verify. This contributes to the portability of programs written in C. Even the compiler writer can transport his tools and programs from an old machine to the new one with a minimum of effort.

Benchmarking

For the record, the evaluation and testing was done on an IBM PC equipped with Intel's 8087 numerics coprocessor, two single-sided 160K-byte disk drives, and PC-DOS 1.1. The machine's 832K bytes of memory were partitioned under PC-DOS to allot 192K bytes for the operating system; the remaining 640K-byte segment was used as a semiconductor disk emulator addressable as any of three logical drives, A:, B:, or C:.

Until performance profiling and execution tracing by function become standard microcomputer software workbench features, the soft spots in software and compiler design remain obscure. In an effort to uncover some of these differences, I included a set of small, simple functions in the evaluation process. These were designed to test separate facets of the compilers' construction and function to show how they vary in incremental code size and execution speed.

The integer math and elemental pointer benchmarks (listings 1 and 2 on page 142) illustrate the simple approach used. The outer-loop count is kept the same in all functions, so its influence is effectively factored out of the results. The integer-math code spends roughly equal processor time in each of the four operators and, by scaling, allows the evaluation to include byte-byte, byte-word, and word-word sized operand pairs. Boundary conditions are intentionally avoided. The pointer function, so simple as to be self-explanatory, is one way to measure efficiency in pointer use for array access.

The benchmark sieve.c is identical (no register variables, no moving the array inside the function body) to the benchmark code published in Jim and Gary Gilbreath's article, "Eratosthenes Revisited: Once More

At a Glance

Name
c-systems C compiler version 1.14

Type of Software Package
C programming language compiler

Manufacturer
c-systems
POB 3253
Fullerton, CA 92634
(714) 637-5362

Price
Compiler: $195
Debugger: $195

Format
5¼-inch double-density single-sided IBM PC-compatible PC-DOS format floppy disks

Type of Compiler
Produces assembly language

Computer Needed
IBM-PC running PC-DOS with two single-sided disk drives and a minimum of 128K bytes of RAM; IBM Macro Assembler required for use

Documentation
46-page loose leaf manual

Audience
Systems and applications software developers, C programmers

Name
Small c: PC 1.1 PC-DOS version N

Type of Software Package
C programming language compiler

Manufacturer
Caprock Systems Inc.
POB 13814
Arlington, TX 76013
(817) 261-4493

Price
$35

Format
5¼-inch double-density single-sided IBM PC-compatible PC-DOS format floppy disk

Type of Compiler
Produces assembly language

Computer Needed
IBM PC running PC-DOS with two single-sided disk drives and a minimum of 64K bytes of RAM; IBM Macro Assembler required for use

Documentation
17-page staple-bound manual

Audience
Experimenters, students, and hobbyists who want to learn more about C

Name
CI-C86 C compiler version 1.33b

Type of Software Package
C programming language compiler

Manufacturer
Computer Innovations Inc.
10 Mechanic St.
Red Bank, NJ 07701
(201) 530-0995

Price
$395

Format
5¼-inch double-density single-sided IBM PC-compatible PC-DOS or CP/M-86 format floppy disks

Type of Compiler
Produces object code

Computer Needed
IBM PC running PC-DOS or CP/M-86 with two single-sided disk drives and minimum of 96K bytes of RAM

Documentation
143-page loose-leaf manual in vinyl ring binder

Audience
Systems and applications software developers, C programmers

through the Sieve" (January 1983, p. 284) and allows general comparison with benchmark figures in that article and in other compiler reviews in this issue. Float.c was used to allow comparison between 8087 use on the PC and other systems that use the 8087 at its full speed, as well as to show the relative performance of the compilers reviewed here. (Refer to "Comparing C Compilers for CP/M-86," on page 82 of this issue for details about this benchmark. You will also find information about benchmarks in Christopher O. Kern's "Five C Compilers for CP/M-80" on page 110.)

The compiler group as a whole showed the least execution time variance in efficiency of function calling (which may explain the close grouping of results from the fibo.c benchmark used in the two articles mentioned above). See tables 1 and 2 for the results of the benchmarks. The greatest variance was for functions measuring performance in address arithmetic. Function-calling measures (with and without argument passing) showed that those compilers that implement register variables always incur a penalty in code size and execution speed, whether this feature is actually used or not. Test results are dramatic and slow some of the top-rated code generators to the crawl of the poorest performers. Quantum C and c-systems suffered heavily from saving the 8088's SI and DI registers on each and every function call, regardless of whether they are actually used, and restoring them both on every return.

Implementation Differences

Peculiarities and variations in how a compiler is written point up some criteria to consider.

Does it use the linker supplied with the native operating system or one of its own unique format? By using the standard linker supplied with the operating system, the compiler's usefulness and flexibility are greatest because assembly language interface is simplified.

Does it generate object code or assembly language? Object-code generation often results in faster compile times and more efficient compiler-code optimization. If assembly language is produced, the effective compiler price must be increased by the $100 price of the IBM Macro Assembler (as in the case of PC-DOS), unless you already own one or (as in the case of the DeSmet compiler) one is provided. Perhaps more important is the time penalty that an assembler extracts from the programmer. On the other hand, assembly-language generation might be necessary if much low-level hardware or operating-system interfacing is needed or if any time- or space-critical code is to be written. If the compiler's output is assembly language, code optimization for speed or compactness offers

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- ☐ Fast Floating Point package
- ☐ Motorola's MACSBUG
- ☐ IDRIS[5] Operating System with C, PASCAL, FORTRAN 77, 68K-BASIC[1], CIS COBOL[4], RDBMS
- ☐ UNIX[2] Sys III C, etc.
- ☐ CP/M-68K[3] O/S with C, Assembler, 68K-BASIC[1], 68KFORTH[1], Z80 EMULATOR[1], APL
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RAM execute time in seconds / Incremental file size in bytes

Compiler Manufacturer	loops.c	control2.c	funcall1.c	intmath3.c	pointer1.c
c-systems	35.8	26.2	15.5	12.3	75.0
	128	512	256	640	128
Caprock Systems (1,2)	133.0	no goto: or case:	25.0	50.7	228.3
	256		384	1920	256
Computer Innovations	31.4	19.7	17.1	13.8	75.2
	84	388	212	612	100
DeSmet	19.9	13.4	10.9	11.6	41.7
	0	0	0	512	0
Intellect Associates (2)	56.8	no goto:	12.2	21.6	98.3
	128		256	371	128
Lattice	19..9	10.7	11.0	7.5	38.2
	0	256	128	256	0
Quantum	20.0	14.0	29.0	12.0	42.0
	74	295	263	510	88
Supersoft	47.0	26.0	12.2	26.3	108.3
	128	640	384	1792	256
Telecon	failed compilation	27.6	11.6	20.0	88.5
		512	256	1024	128

(1) 'puts' substituted for 'printf'
(2) 'while' loops in place of 'for' loops

Table 1: *Code generation and execution times of the standard BYTE Sieve of Eratosthenes benchmark* sieve.c *and a floating-point benchmark* (float.c) *for those C compilers that support floating-point operations. Times are given in seconds for both the floppy disk and memory disk emulation modes.*

faster development than coding from scratch in assembly language.

Are libraries standard and Unix compatible? Libraries of nonstandard functions may perform as well as or better than the standard functions on some specific machine, but when it comes time to move the code to another processor, the lack of standardization can prove expensive. Subtle differences in microprocessor libraries center around what a system call, in Unix, would directly or indirectly accomplish. Popular microprocessor operating systems require that subroutines simulate these calls. In particular, the areas of file and byte-stream I/O (especially open and fopen) are subject to small variations in implementation to make up for the lack of capability in the surrounding operating system. (Table 3 on page 166 lists a full complement of standard, single-user functions.)

The c-systems compiler, which implements a nonfloating-point subset of C, does not yet allow cast operators or typedef declarations (although the developers expect to offer a fully standard implementation of C, including these abilities and floating point, by

sieve.c Compiler Manufacturer	Compile Time Floppy	Compile Time Memory	Link Time Floppy	Link Time Memory	Code Size File	Code Size Incremental	Execute in RAM
c-systems (3)	55	28.0	45	21	26368	15360	19.8
Caprock (1,2,3)	44	27.7	14.2	3.7	12800	8704	69.3
Computer Innovations	51	11.8	45	18.5	12864	234	17.4
DeSmet	41	3.8	40	4.6	6144	0	12.1
Intellect (1)	19	3.3	13	4.0	8704	8576	31.3
Lattice	33	7.2	40	10.5	19328	8320	11.3
Quantum (3)	39	8.0	42	14	11513	8384	12.6
Supersoft (3)	88	53.0	40.5	11.2	24960	8704	31.3
Telecon (3)	51	28.9	29	10.7	16256	8448	25.0

float.c Compiler Manufacturer	Compile Time Floppy	Compile Time Memory	Link Time Floppy	Link Time Memory	File Size	RAM Execution Library	RAM Execution 8087
Computer Innovations	47.1	9.9	35	19.2	13052	805	45.3
DeSmet	41	4.7	39	4.9	6656	296	22.0
Lattice	34	5.2	41	10.3	12288	286	—
Quantum (3)	38	8	44	17	3367	—	13.0

(1) 'puts' substituted for 'printf'

(2) 'while' loops in place of 'for' loops

(3) compilation time includes assembly

Table 2: *Incremental file sizes (factoring out the size of the library overhead) and execution times of some single benchmark functions.*

August). The 60 library routines and macroinstructions supplied include useful, PC-specific, BIOS (basic input/output system) interface and video-display utilities, and the runtime package supports I/O redirection. As this article was written, the c-systems compiler and Digital Research C (for CP/M-86) were the only ones available that implemented multiple memory models, although others were imminent. The c-systems compiler, in addition to the usual small model, includes a command-line option and library for the medium model as well. Figure 1 illustrates the variety of models available.

While not an outstanding performer in terms of code size, compile time, or execution time relative to others reviewed, the c-systems compiler's unique and innovative options make it a useful tool. Integer math and local-variable access benchmarks produced relatively efficient code, but performance lagged somewhat in control-mechanism efficiency testing. Function calling was burdened with the register variable mechanism, saving and restoring SI and DI registers on each call and return. Code-

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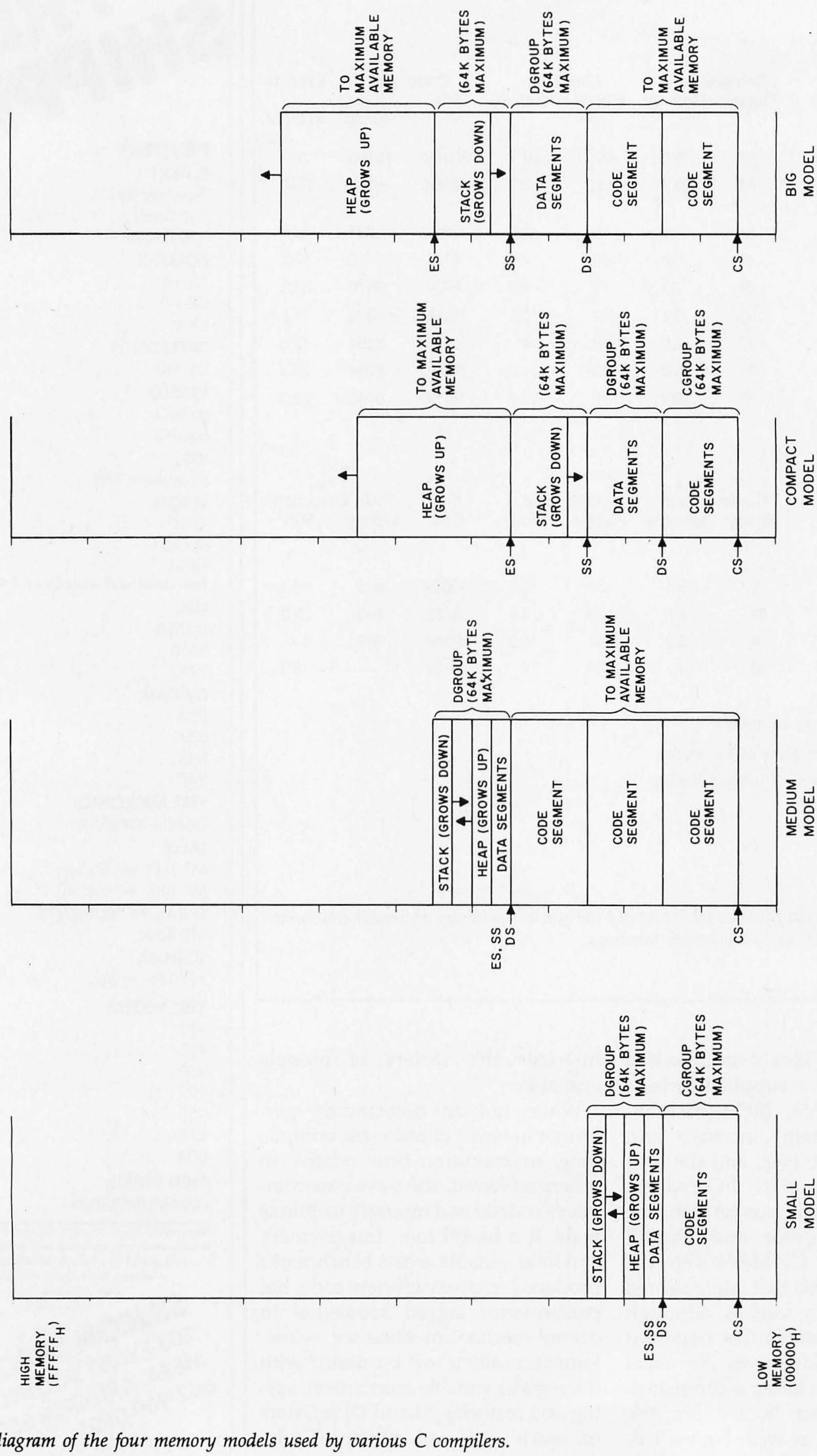

Figure 1: *A diagram of the four memory models used by various C compilers.*

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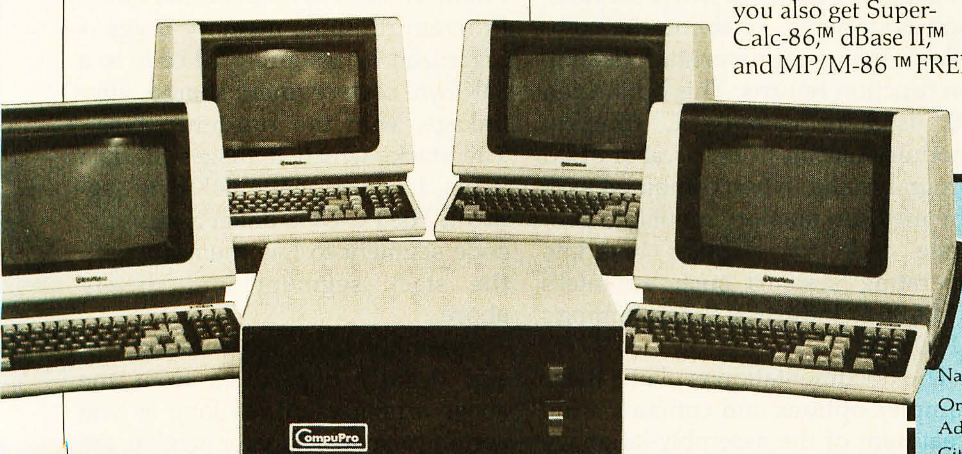

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Memory Models

A thorough understanding of the models employed to structure memory usage beyond the familiar 8-bit processor, 64K-byte domain is necessary. The revolutionary innovations in software design will not come from using this newly available memory resource for more spreadsheet arrays or a bigger memory disk emulator. Real innovation and creative design can only progress when the tools are available for concrete realizations.

Two compiler manufacturers (c-systems and Digital Research) are already supporting larger memory usage, one has two additional memory models in test sites (Lattice), and at least two others (Mark Williams and Mark DeSmet) have definite plans for supporting larger models in the near future. The tools are here; we need to know how they work.

Although the Intel 8088 microprocessor used by the IBM Personal Computer can directly address over one million bytes of semiconductor memory, the manner in which this space is accessed leads to compromises in both hardware and software architectures. For the processor to retain a 16-bit internal datapath (assuring relative ease in software migration from earlier Intel products), a segmented architecture was chosen.

To generate the 20-bit physical address needed to reach any location in the memory space, the bus-interface unit of the processor automatically shifts the 16-bit contents of one of the four segment registers left by four binary bits (filling the spaces created on the right with binary zeros) and internally adds this result to a 16-bit register containing an offset address. Therefore, to reach any memory with a physical address outside a 64K-byte span, the appropriate segment register must be adjusted. The processor takes fewer clock cycles to operate within a 64K-byte logical address space and requires additional cycles for any memory transactions outside that limit. The compiler designer wishing to enable access to code or data spaces beyond 64K bytes faces a confusing thicket of tradeoffs as a result of this complex process.

To deal with this complexity, C compiler writers for Intel's 16-bit architecture are choosing to adapt the four memory models expressed in the Intel PL/M-86 object format (see figure 1). The most widely used model, and the default model for most compilers, is the small memory model, which defines separate code and data areas, with a maximum size of 64K bytes each for a total program memory access to 128K bytes. All code must fit within the code group; the 8088 CS register is used as relative origin. All data and the stack must fit within another 64K-byte area with the DS, ES, and SS registers all pointing to its origin and defining the lowest accessible address. Within this data area the stack grows downward from the highest available data memory, and the dynamically allocated heap area, generally based on the 8088's ES register, grows upward from the top of whatever memory the compiler has allocated as a fixed area for globally available variables and data.

The medium model still restricts its programs to a maximum of 64K bytes of data, apportioned identically to the small model, but code is allowed to expand to the limit of maximum available memory. The compiler and linker normally manage the CS segment register to generate the optimally appropriate form of call and return. A third model, the compact model, limits code and

production times were impeded by the use of the snail-like PC assembler. Sieve execution performance improved by 22 percent when register variables were used for the loop indexes.

The company's c-window symbolic debugging package, available for $195, is a unique and valuable option worth noting. When the user sets a compiler command-line option (the debugger works only with the c-systems compiler), provision is made to link a separate library containing a program-execution supervisor. When the compiled program is run, high-level debugging using single-step, trace, or breakpoint is supported with breaks conditional on count, function name, and source-line number or by nonzero evaluation of arbitrarily complex user-defined expressions. Extensive user-specified automatic commands allow the setting or display of evaluated expressions, variables, and data with radices and formats precisely predetermined.

Another interesting command-line option allows the user to set a PL/M- and Pascal-compatible argument-passing convention. Compared to C, arguments are placed on, and removed from, the stack in inverse order. Because C allows a variable number of arguments to be passed into a function, all arguments must be explicitly declared when the function is declared, enabling the compiler to generate proper stack cleanup on function returns. This option can be used to compile C function modules callable from Pascal or PL/M programs and, when combined with the medium memory model, to generate code for popular real-time operating systems such as Intel's RMX-86 or Industrial Programming's MTOS-86.

The documentation explains these complex options and contains a full treatment of the assembly-language interface to c-systems code. However, while the 46-page manual is accurate, complete, and useful, it includes neither an index nor error message explanations. An alphabetic reference list of the library functions would be a welcome addition.

Caprock small-c is a result of Ron Cain's generosity (i.e., it is a translation of source code intended for the 8080, originally published in *Dr. Dobbs' Journal* #45 and placed in the public domain by Cain at that time). Program run-time memory usage is organized by assigning all code to a 64K-byte code segment shared, after linkage, with the run-time library. The stack, which manages all data items, has a separate 64K-byte segment. The PC-DOS linker assigns the code segment to low memory, with the stack segment immediately above.

Assembly language provides for any desired departures from the above arrangement, as long as you assume responsibility for juggling the segments. In contrast to the original small-c, the compiler can produce multiple output files and supports true extern linkage, so the entire run-time library source is not required as

external variables to 64K bytes each and allots a full 64K bytes for stack data, with the CS, DS, and SS registers adjusted accordingly. The heap data area employs the ES register, growing upward, and can occupy up to all of the remaining memory. The amount of memory allotted to heap use is generally specified at link time.

The final model, the big model, is a deviation from the PL/M-86 convention's large model plan. In the PL/M-86 model, each code segment allocation should be able to access its own 64K-byte data segment. C compiler writers have settled on a less ambitious scheme, where a program is limited to a single 64K-byte data space for global data, a single 64K-byte stack area, but allowing code and heap allocations to divide up the remaining memory with the heap left to manage whatever is not used by the program code.

In the words of its progenitors, "C is not a 'very high-level' language." A programmer can get close to and manipulate the details of individual machines. Therefore, a few ramifications to all of the above exist that govern C compiler design and should influence the C programmer's choices and coding practices. Under the small model, the natural integer size and natural pointer size for C are both 16 bits, a fact that allows maximum efficiency in using the 8088 processor and a minimum of confusion for the programmer. In the big model, the natural size for C int *and pointer types is 32 bits, and while the processor takes longer to juggle 32 bits than 16, this concerns the programmer solely from a code size and performance standpoint.*

With the compact and medium models, care must be exercised. In the compact model all function calls are short (16 bits), but the dynamic data must be managed in C using 32-bit data pointers, loads, and stores. Thus char *pointer and natural integers are not all the same size, and care should be exercised in the use of casts and type conversions. The medium model, which allows* long *calls but restricts all stack and data to 64K bytes, reverses the implications of the previous anomaly if you want to use pointers to functions or manipulate code addresses directly.*

compiler input along with the user's program. The assembly-language interface is adequately documented and is aided by the directives #asm and #endasm for including in-line assembly statements in the C source file.

While quite inexpensive, the Caprock small-c lacks many of the features that make C the powerful systems tool it is. For instance, the control structures while, for, switch, and goto are missing. This subset does not support the storage classes auto, static, and register; typedef declarations; float or long int data types; conditional compilation (#ifdef, etc.); arguments for #define preprocessor statements, initializers on declaration or casts; and multidimensional arrays, structures, and unions are not allowed. Functions may only return int, pointers may only point to char or int, and no complex assignments are permitted. Caprock small-c does not support conditional expressions, comma, logical negation, and one's complement.

In performance, small-c came in last in every test of execution speed and behind most of the others in code size and compile time. The interactive nature of the command mode is inoffensive, but assembly durations require patience.

Why, then, is such software useful? First, as the least expensive C compiler available for the PC, it can give the programmer a taste of the language without a large cash investment. Beginners at programming should know, however, that using small-c as a means to learn programming or to learn C can be extremely frustrating at best because so much of the language is absent. Most programs from books or magazines will simply not compile or run without significant alteration. Such changes are best left to the experienced.

Caprock small-c could also be used as a learning aid for the C programmer. The source code for the entire compiler and run-time library is included on the disk; it is a unique aid for anyone interested in studying and tinkering with the mechanics of compiler construction. And because the disk includes a translation, into C source, of the text-formatting program from Kernighan and Plauger's classic text, *Software Tools*, it is a valuable resource for the student learning how to translate into C from another language (RATFOR preprocessed FORTRAN or Pascal, depending on which version of the book you use). As a bonus, the executable version provides some useful word-processing capabilities when combined with a trusty text editor.

Computer Innovations C86: In addition to the three-pass compiler and complete source-code files for the assembly language and C library functions, this package includes an object-code librarian, object libraries, a linker, and a source-code library-maintenance program that allows many small code files to be stored in one archive, eliminating disk-file clutter and freeing disk-directory entries.

The CI-C86 compiler accepts the standard C language and produces object code in a format exclusive to the system linker. Register variable declarations are converted to auto (storage class), and true register variables are slated for a future release. A command-line option allows 31 character identifiers, a feature that increases the self-documenting qualities of the resulting code but makes it more difficult to transport. Other compiler options enable comments to nest and permit the entry of command-line #defines. Error messages are accompanied by the line number the compiler was working on when the error was detected. An interim solution to interfacing assembly-language to a nonstandard object-module environment is provided by a program that converts an assembler's output to a form acceptable to the CI-C86 linker.

Although only the small memory model is implemented, the package includes a software foundation for using overlays. Library routines enable program I/O redirection. The 8087 math coprocessor is supported by calls to library functions, and in-line code capability is scheduled for

Text continued on page 146

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Listing 1: *The math benchmark.*

```
/*      intmath3.c                  */

#define COUNT 10000

main( )
{
    int i, j, k;
    printf( "Starting\n" );
    for( i = 0; i < COUNT; ++i) {
        j = 240; k = 15;

/* test byte-byte combinations */
        j = (k * ( j / k ));
        j = (k * ( j / k ));
        j = ( k+k+k+k+ k+k+k+k+ k+k+k+k+ k+k+k+k );
        k = (j -k-k-k-k -k-k-k-k -k-k-k-k -k-k-k );

/* test byte-word combinations */
        j = (j << 4); k = (k << 4);
        j = (k * ( j / k ));
        j = (k * ( j / k ));
        j = ( k+k+k+k+ k+k+k+k+ k+k+k+k+ k+k+k+k );
        k = (j -k-k-k-k -k-k-k-k -k-k-k-k -k-k-k );

/* test word-word combinations */
        j = (j << 4); k = (k << 4);
        j = (k * ( j / k ));
        j = (k * ( j / k ));
        j = ( k+k+k+k+ k+k+k+k+ k+k+k+k+ k+k+k+k );
        k = (j -k-k-k-k -k-k-k-k -k-k-k-k -k-k-k );
    }
    printf( "Finished\n" );
}
/*      intmath3.c      end      */
```

Listing 2: *The pointer benchmark.*

```
/*      pointer1.c                  */

#define COUNT     10000
#define ALLOTTED 128

main( )
{
        char workarea[ALLOTTED], *ptr;
        int i;
        printf( "Starting\n" );
        for( i=0; i < COUNT; ++i) {
                ptr = workarea;
                while(ptr < (workarea + ALLOTTED)) {
                        *ptr = ' ';
                        ++ptr;
                }
        }
        printf( "Finished\n" );
}
/*      pointer1.c      end      */
```

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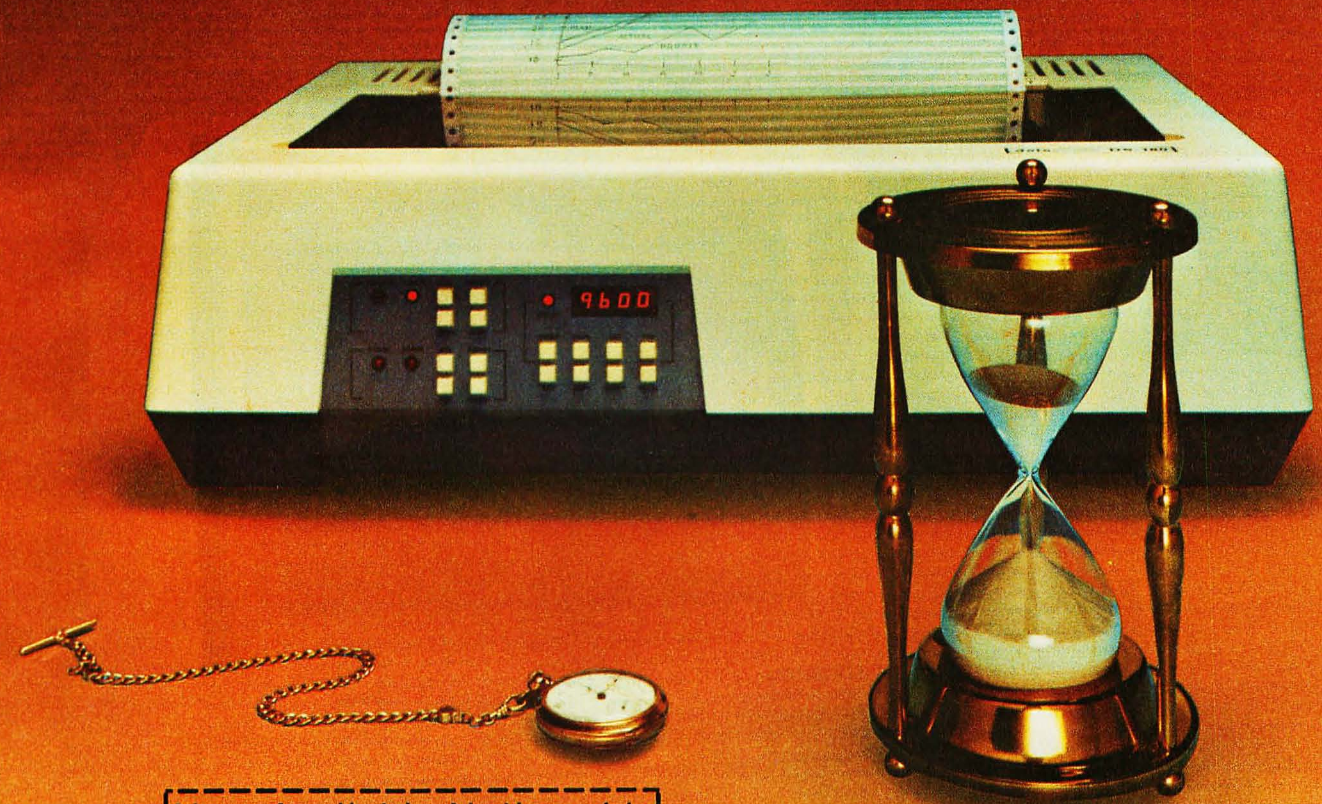

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Text continued from page 141:
future release.

More than 100 library subroutines include several utilities for math, memory management, and string manipulation. Two important library functions behave differently with respect to the standard, so migrant code may need adjustment: the CI-C86 I/O subroutine fopen employs a 12-choice mode argument, rather than the usual 3-choice mode, to accommodate CP/M end-of-file conventions and to differentiate between binary and ASCII files. The CI-C86 open system-call simulation requires a 6-choice mode for similar reasons. The formatted I/O functions include the nonstandard, but welcome, extension of capability in the inclusion of a binary radix.

The manual's coverage of this particular implementation of C is a bit thin. The individual programs included are documented in clearly structured style, but error messages are neither listed nor explained, and the descriptions of the programs and routines are often terse. The alphabetic listing and clear one-to-a-page format of library-routine documentation, however, make for easy reference.

This widely used compiler has been the subject of continual work and improvement since its introduction, and it will probably continue to improve. C86 was relatively inefficient at function calling, a drawback unrelated to overhead of register variables because the register type is converted to auto. Code generated for integer math and local-variable access was relatively efficient compared to others.

In use, C86 is simple and straightforward and complicated only by the need to manage the nonstandard linker's syntax. Error messages can be confusing if they don't offer additional documentation, but a provision to print a source listing after the preprocessing pass can be a useful debugging tool. By including source code for the run-time subroutine library, Computer Innovations gives the user greater control over the structure of the final executable code module. While I found no real basis for complaint about this product,

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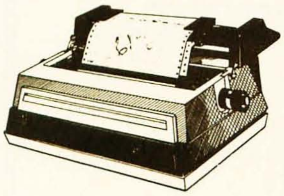

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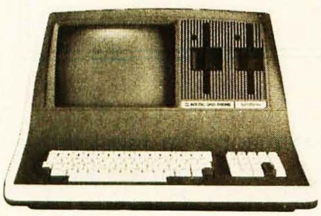

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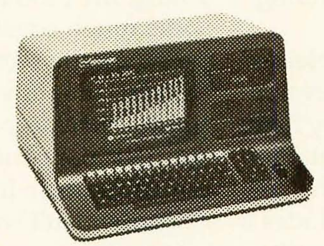

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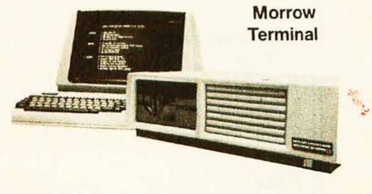

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Documentation
105-page loose-leaf manual

Audience
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Name
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Type of Software Package
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POB 365
Holbrook, NY 11741
(516) 472-4449

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Computer Needed
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Audience
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Name
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(312) 843-2405

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Documentation
162-page staple-bound loose-leaf manual

Audience
Systems and applications software developers, C programmers

neither its features nor its performance were relatively outstanding.

Mark DeSmet has recently released a full suite of 8088 systems-development software accompanied by more than 100 pages of documentation. Available from C-Ware for the low price of $100, the package includes a two-pass compiler, screen editor, assembler, linker loader, cross-reference and list utility, object-code librarian, and two valuable system-utility programs in both source code and executable form. The run-time library is supplied in two versions; one provides 8087 coprocessor floating-point support, and the other provides software floating-point subroutines.

The extent and quality of these programs are amazing. The DeSmet conpiler was usually fastest in compilation and linkage times, regularly produced tight code and small incremental program size, and always ranked at the top in terms of execution speed. Because it is relatively young, the product is bound to have some rough edges. For instance, the preprocessor section of version 1.5 failed to properly handle tests of intricate `#define` expansion, producing spurious code with no compile-time error indication. In all other tests run, no further fault was found with compiler accuracy.

This system produced consistent optimization in both code size and execution speed and generated code that consistently outperformed all but the Lattice compiler. In the short history of this product, C-ware seems committed to continuously improving it and has already added substantially to the library. The DeSmet package is an unsurpassed vehicle for programmers in other languages (particularly assembler) to use in learning C. Examples of C and assembly-language source files that are included deftly illustrate the range of capabilities available.

Although it does not support Unix version 7 extensions, in most other respects the DeSmet compiler accepts the entire standard C syntax, including all widely used data types and operators. For example, the only pre-Unix version 7 data type missing is `short`, which may be added by employing `typedef`. Extensions are made to support 31-character variable names (for more readable code) and to include assembly language in line via the `#asm` preprocessor directive. Console I/O is not provided with redirection in the current release, and only the small memory model is presently supported.

A full-facility programmer's tool, the screen editor has an elegantly simple command syntax. The assembler includes all 8087 coprocessor mnemonics and uses a syntax that differs only slightly from that of Intel's ASM-86 standard. Bind, the system's linking loader, is used to produce executable files from the object output of both the assembler and the compiler. It produces a full sorted

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list of public symbols with corresponding segment locations and offsets. A utility program, clist, produces paginated source listings with line numbers, fully formatted for printing, and includes a cross-referenced listing of all functions and all line numbers where they were found. Object libraries included can be called from either C or assembly language, and both options are clearly explained.

The object library supplied consists of 59 subroutines. An additional 16 routines for IBM PC screen and keyboard handling are included in a separate assembly-language source file that may be assembled and linked with C or assembly-language object modules. A C implementation of the game of Life, invented by English mathematician John H. Conway, is included in both executable and source-code forms to illustrate the use of this comprehensive assembly-language PC screen handler.

Two other source files accompany this package. A core-style file-dump utility illustrates the use of file and screen I/O routines. An assembly-language source file for an operating-system utility patch, which extends the keyboard input buffer from its current 15 to a full 128 characters, illustrates use of the system assembler. Both are included in executable form and are valuable as programs and as examples.

Although brief, the documentation devotes just enough attention to each feature in this extensive package to supply the user necessary information. The lack of an index seems less noticeable here than in some other documentation due to the clear structural organization and the inclusion of a functionally subdivided listing of library routines in the table of contents. All programs include extensive error messages, which are fully documented.

Intellect Associates C88 is a one-pass, nonoptimizing, integer-only subset compiler that seems to be constructed on a foundation of the public-domain small-c source but incorporates many enhancements. Memory usage is limited to the 64K-byte 8080 .COM file format, with the origin of a user's program set at the address 100 hexadecimal. The somewhat nonstandard subset of C this compiler supports is limited, but fortunately the documentation clearly outlines what is missing. A function library consisting of 44 individual object files requires the supplied linker to form an executable file. No run-time I/O redirection for the user's programs is supported. Modules may be compiled without a main,so they can be used as subroutines in addition to the object files supplied.

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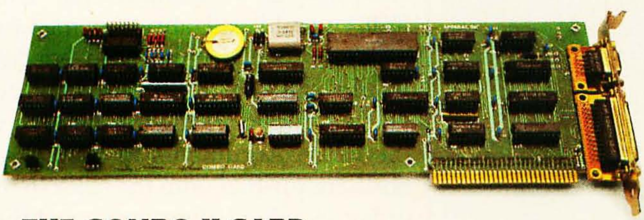

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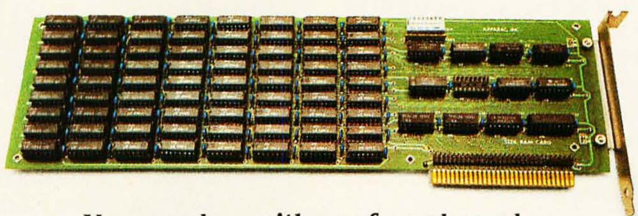

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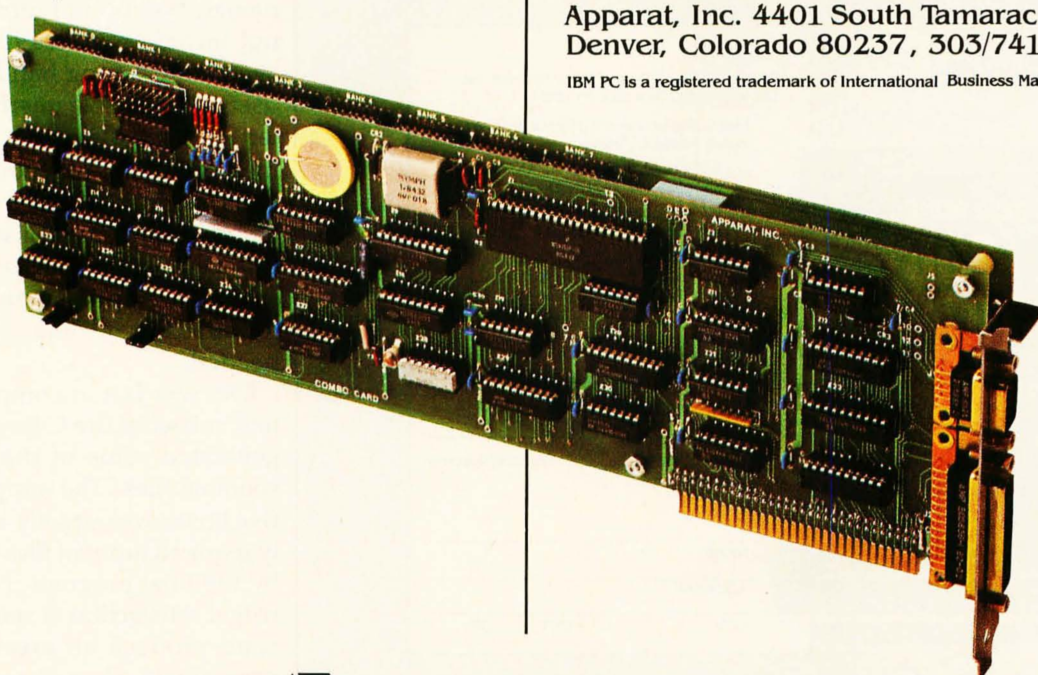

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syntax—will double the subscript evaluation. Arguments to #defines are not permitted, and #includes may not nest.

All constant expressions are evaluated at run-time (rather than at compile time, which would be faster), and function arguments must be defined in the order in which they appear in the function declaration. The compiler considers all undeclared but referenced functions or variables to be external functions and sends necessary external references to the object file. The user must examine the list of external identifiers printed at the end of compilation for incorrect entries such as misspelled variable names.

Function calls have a decidedly nonstandard but potentially interesting feature for the absolute-address adventurer. Almost anything you can imagine immediately followed by ((the open parenthesis) is compiled as a function call. Thus 1000( ) would call absolute memory location 1000 decimal and array[i]( ) would call the location whose address is found in the ith member of the array. Arguments to such functions are pushed onto the stack in the order in which they appear within the parentheses.

Most of the object files that constitute the library have nonstandard names, syntax, and functions and do not include routines for heap management or string handling. Several useful PC console interface, BIOS interface, special-purpose disk I/O, and memory-utility functions are also on the disk. The 60 pages of documentation are neither well structured nor oriented to the novice. After considerable groping about, however, I found most of the information I needed.

C88 was fast at compiling its limited subset of the C language, and it generated some of the smallest executable files. The supplied interactive linker was equally rapid and only required input of files actually used by the final program. I felt a certain frugal satisfaction at seeing this software produce an executable utility program to clear the PC's display screen that occupied only 128 bytes

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on the disk. Other compilers impose a minimum overhead of 6 to 10K bytes on executable files by including mandatory I/O redirection, even for those programs where this is unused and totally inappropriate. However, the performance of the code generated, especially in such critical areas as looping and local-variable access, is inadequate for any serious production work, particularly when compared to the price/performance ratio of other available software.

Lattice C, in addition to the two-pass compiler, includes a standard library in object form, an object module disassembler, three header files, a source function-extraction utility, and sample C source files. A run-time package supports full I/O redirection. The 150-page manual includes a detailed table of contents and a comprehensive index. With the addition of an object-code librarian, this compiler is marketed as the Microsoft C compiler.

The Lattice C compiler produces remarkable code. In integer and floating-point math evaluation, pointer and array handling, local-variable access, and function calling, performance was outstanding in terms of both execution speed and code compactness. Most measures applied to the compiler group echoed this superiority. Not only was the code fast and compact, but the Lattice compiler was consistently second only to the DeSmet compiler in compiling and linking speed in both memory-disk emulator and floppy-disk environments.

Rapid compilation and high-performance code are crucial in a product-production environment where they facilitate an interactive "successive approximation" style of coding. This compiler encourages the programmer to code in small units, testing each as he goes, rather than build untested monoliths that require laborious debugging.

In extensive use over an 8-month period, the Lattice compiler has performed reliably and predictably, even when facing intentionally nasty traps and errors. The preprocessor handles

Text continued on page 158.

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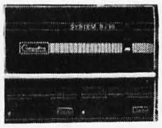

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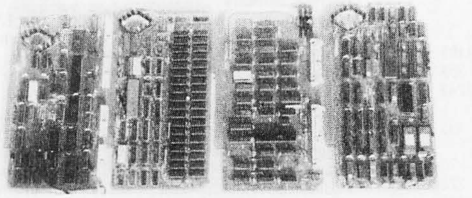

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2 USER MPM 86, 86/89, 256K, 10 SLOT, 2-8"	3895.
5 USER MPM 86, 86/89, 512K, 10 SLOT, 1-8" 8MBHD	6595.
5 USER MPM 86, 86/89, 512K, 10 SLOT, 1-8" 32MBHD	8095.
4 BOARD SET AUGUST ONLY, 86, LDP72, HAZ, 256K	1399.
8MHZ 8086 $420., LDP72 $220., HAZITALL	$260.
10MHZ 8086 $520. 128K STATIC $875. 256K DRAM	636.

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Versaform-Pascal	245	180
Versaform/Corvus Hrd Disk	495	360
ARTSCI		
Magic Mailer	70	49
Magic Pack Combo	225	156
Magic Window	100	75
Magic Window II	150	109
Magic Words	70	49
Avant Garde		
Ultra Plot/DIF/Datagraph	99	71
Beagle Brothers		
Apple Mechanic	30	22
Beagle Bag	30	23
DOS Boss	24	17
Double Take	35	27
Flex Text	30	23
Pronto DOS	30	23
Utility City	30	22
BPI		
GL, AR, AP, Payroll, JobCost, Inventory (ea)	395	320
Broderbund Software		
Bank Street Writer	70	53
General Ledger w/AP	495	305
Payroll	395	275
Computer Station		
Combined Enhanced Graphics	55	40
Station Master	175	136
Comshare		
Image Maker	175	126
Continental Software		
CPA #1,2,3,4 (all 4) [5]	1000	609
CPA #1-GL	250	159
CPA #2-AR	250	159
CPA #3-AP	250	159
CPA #4-Payroll	250	159
CPA #5-Property Management	495	352
FCM (First Class Mail)	100	75
Home Accountant	75	52
Crane		
Menu Generator	40	29
Creative Curriculum		
Speed Reading Courseware	99	75
Dakin 5		
Business Bookkeeping System	395	299
Budget Planner	150	112
Depreciation Planner	395	299
Datamost		
Reap (Real Estate)	130	90
Tax Beater	130	90
Write On	130	99
Datasoft		
BASIC Compiler	100	75
Lisp Interpreter	125	94
Micropainter	35	25

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Accountant with DBCalc	149	112
DBCalc	0	20
Delta Software		
Bookkeeper Check Writer	40	29
Bookkeeper Master	90	68
Denver		
Financial Partner	250	188
Pascal Programmer	296	223
Pascal Tutor	125	97
Eduware		
Algebra 1	40	30
Algebra 2	40	30
Algebra 3	40	30
Algebra 4	40	30
Algebra 5 & 6	50	38
Compu-Math/Arithmetic Skl	50	37
Compu-Read	30	22
Compu-Spell/Data Disk 4-8 (ea)	20	15
Compu-Spell/System	30	22
Counting Bee	30	22
Decimals	49	37
Fractions	49	37
Metri-Vert	16	12
Perception	25	19
PSAT Word Attack	49	37
Rendezvous	40	30
SAT Word Attack	49	37
Spell Bee w/Reading Primer	40	30
Statistics	30	22
GL, AR, AP, Payroll, Job Cost, Inventory (ea)	395	320
Hayden		
Piewriter/Multi 80 Column	150	108
Piewriter/Standard	150	108
Hayes		
Micromodem II w/Term Pgm	409	289
Terminal Program	100	75
Highlands		
CRAE	40	30
EZ Ledger	60	37
MCAT	25	19
Howard		
Creative Financing 1983	195	149
Real Estate Analyzer	195	146
Tax Preparer 1983	225	179
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Datadex	150	108
Datadex/Hard Disk	300	216
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Forth Development System	140	101
Tellstar Level 1	40	30
Tellstar Level 2	80	58
Insoft		
ALD System II	75	56
Electric Duet	30	23
Graforth II	75	56
Transform II	125	94
ISM		
Graphmagic	90	65
Mathemagic	90	65
Kensington		
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Master Type	40	30
Link Systems		
Data Fax	199	149
Data Link	100	75
Link Disk	70	51
Link Index	195	149
Link Sampler I	60	45
Link Video	55	42
LJK Enterprises		
Data Perfect	100	78
Edit 6502	100	78
Lettr Pefct w/Mail Merge	150	112
Lotus		
Executive Briefing System	199	149
Micro Lab		
Asset Manager	200	144
Data Factory	300	216
English SAT #1	30	22
Invoice Factory	200	144
Learning System	150	108
Merger	50	37
Painter Power	40	30
Payroll Manager	300	216
Tax Manager	180	129
US Constitution Tutor	30	22
Visiblend	50	37
Visifactory	75	54
Wall Streeter	300	216
Microsoft		
Applesoft™ Compiler™ (TASC)™	175	119
Multiplan™	275	198
µMath/µSimp™ (ADIOS)	250	194
Time Manager™	150	116
Typing Tutor II™	25	19
Muse		
Address Book	50	36
Dataplot	60	43
Elementary math	40	29
Form Letter Module	100	75
Supertext Home Office	125	94
Supertext Professional	99	74
The Voice	40	29
Omega		
Inspector	60	49
Locksmith	100	75
Optimized System Software, Inc.		
Speed Read Plus	60	43
PBL		
Personal Investor	145	99
Penguin		
Additional Fonts Char Set	20	15
Comp Graphics/Apple Tablet	120	86
Complete Graphics System	70	50
Graphics Magician	60	45
Special Effects	40	30
Special Effects Apple Tablet	70	50
Phoenix		
Zoom Graphics	50	38
Program Design		
New Step-By-Step	80	58
Step by Step II	90	70
Quality Software		
Bag of Tricks	40	30
GBS—DB Appl Dev Program	650	488

Product	LIST	SALE
Sensible		
Applesoft + Struc. BASIC	40	30
Best	40	30
Bug, The	50	32
Build Using	30	23
Disk Organizer	30	23
Disk Recovery	30	23
DOS Plus	25	19
Edit Soft	40	30
Image Printer Epson	40	30
Image Printer Letter Qual	40	30
Image Prtr NEC/Dot Matrix	40	30
Multi Disk Catalog	25	19
Quadrant 6112	30	23
Quickloader	25	19
Sensible Speller	125	94
Sensible Speller Pascal	125	94
Sens. Speller Word Handler	125	94
Super Disk Copy	35	26
Sierra On Line		
Dictionary	100	70
EPF IV	80	56
General Manager II	230	168
LISA	80	56
LISA Educational System	120	83
Screenwriter II	130	85
Screenwriter Professional	200	149
Silicon Valley		
Dictionary	125	94
List Handler	90	68
Word Handler	199	145
Sirius		
Pascal Graphics Editor	100	75
SOF/SYS		
Executive Secretary	250	188
Executive Speller	75	56
Softech		
BASIC Compiler & Runtime [5]	225	169
Softeach	125	94
UCSD p-System Set [5]	625	469
Xenofile	50	39

Apple IIe

Most Apple II products also run on the IIe (call for details). Products below are specially designed for the IIe.

Product	LIST	SALE
Software Dimensions		
Accounting + IIe		
AP	395	289
• AR	395	289
• GL	395	289
• Inventor	395	289
• Payroll	395	289
• POE	395	289
• POS	395	289
• SOE	395	289
Software Publishers		
PFS: File	125	94
PFS: Graph	125	94
PFS: Report	125	94
Visicorp		
Visicalc	250	189

Product	LIST	SALE
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Datamost		
Write On	130	99
Denver Software		
EASY	750	562
Insoft		
ALD System III	75	56
Transforth III	125	94
Link Systems		
Data Fax	249	187
Link Index	195	149
Link Sampler I	60	45
Link Video	55	42
Software Publishers		
PFS: File	175	129
PFS: Graph	175	129
PFS: Report	125	94
Visicorp		
Business Forecasting Model	100	78
Desktop Plan	300	234
Visicalc Advanced	400	312
Visischedule	300	234

Apple Hardware

Product	LIST	SALE
Eastside		
Wildcard	130	109
Hayes		
Micromodem II [5]	379	259
Kensington		
System Saver Fan	90	69
Kraft		
Joystick	65	49
LJK		
Lower Case Char Gen	25	19
Micro-SCI		
A2 35T Disk Drive	479	329
Microsoft		
16K Ram Card™	100	69
Premium System™ [5]	695	489
New Premium Card (32K printer buffer, 256 byte type ahead, 64K memory, 80 col., CP/M	495	369
Softcard™	345	219
Personal Computer		
Applicard 6 MHz	595	449
TG Products		
Joystick	60	45
Selectaport	60	45
Trackball	65	49
Versa Computing		
Versawriter Graphics Tablet	299	249
Videx		
Enhancer II	149	119
Function Strip	79	65
Inverse Character Set	29	24
Lower Case Chip	29	24
Lower Case Chip (Rev 0-6)	35	29
Micromodem Firmware	29	24
Soft Video Switch	35	29
Videoterm Switchplate	19	16
Videoterm with Softswitch	375	239

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Adventures 1-12 (Req Z80)	129	97
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Power for CP/M	75	54
Anderson-Bell		
ABSTAT		359
Artificial Intelligence		
Dental (PAS-3)	995	749
Medical (PAS-3)	995	749
Ashton-Tate		
Bottom Line Strategist	400	279
dBASE II [5]	700	398
dBASE II w/User's Guide [5]	729	419
Aspen Software		
Grammatik	75	56
Proofreader	50	38
Balcones		
BOSS Fin. Acctg System	2495	1496
Byrom Software		
BSTAM	200	149
BSTMS	200	149
Caxton		
Cardbox	245	177
Comm soft		
Roots/M	195	142
Computer Control		
FABS-BTree File Access	195	146
Ultrasort II	195	146
Computer development		
Image	495	356
Comshare		
Planner Calc	99	74
Target Application Guide	50	38
Combo Pak	125	94
Condor		
Condor 1	295	189
Condor 3	650	398
Designer Software		
Palantir	425	319
Dictronics		
Random House Thesaurus	150	113
Digital Research		
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CIS Cobol	800	595
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Pascal MT+ with SPP	500	395
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SID	75	63
SPP	200	150
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FMS 80-2	495	312
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Citation	250	169
Ecosoft		
Microstat	295	248
Microstat 3.0	395	320
Epic		
Supervyz	150	94
Faircom		
Micro B + (CBasic)	260	211
Micro B + (Other)	260	211
Fox & Geller		
dGRAPH	295	195
dUTIL	99	59
Quickcode	295	195
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Quickscreen/dBASE II	149	125
Quickscreen/FMS-80	149	125
Quickscreen/MBasic	149	125
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Superfile	195	129
Human Soft		
dBPlus	125	95
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Starcross	50	38
Suspended	50	38
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Zork II	50	38
Zork III	50	38
ISM		
Mathemagic	100	72
Ithaca Intersystems		
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Pascal Z	450	375
Pascal Z & BZ	650	542
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Spellbinder	495	281
Metasoft		
Benchmark Mail List	250	184
Benchmark Wordprocessor	500	367
Calcstar	145	96
Datastar	295	195
Infostar	495	327
Mailmerge	250	165
Reportsrar	350	231
Spellstar	250	165
Supersort	250	165
Word/Mail [5]	695	426
Word/Spell [5]	695	426
Word/Spell/Mail [5]	845	558
Wordmaster	150	99
Wordstar [5]	495	327
Microsoft		
BASIC 80™	350	252
BASIC Compiler™	395	296
COBOL 80™	750	562
FORTRAN 80™	500	360
MACRO 80™	200	150
µLips/µStar™	200	156
Multiplan™	275	198
µMath/µSimp™	250	194
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Text Editor™	120	94
Microstuf		
Crosstalk/Smartmodem	195	135
Northwest Analytical		
Statpak	495	369
Oasis		
The Word Plus	150	112
Organic Software		
Datebook	295	229
Milestone	295	299
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• AR	600	398
• GL	600	398
• Inventory	600	398
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• GL	750	515
• AP	750	515
• AR	750	515
• Inventory	750	515
• Payroll	750	515
• Sales Inv.	750	515
Peachpak Series 9	500	345
• Mailing List	375	258
• Peachcalc	375	258
• Peachtext	500	345
• Proofreader	300	206
• Telecom	375	258
Series 40 Pak (GL,AR,AP)† [5]	595	398
• AP†	400	275
• AR†	400	275
• GL†	400	275
Series 80 Pak (GL,AR,AP)† [5]	595	398
• AP†	400	275
• AR†	400	275
• GL†	400	275
• Inventory†	400	275
Pearl Soft		
Personal Pearl	295	184
Quality		
GBS—DB Appl Dev Prog	650	488
Select		
Select Word Processor	595	356
Sensible		
Sensible Speller†	125	94
Software Dimensions		
Accounting + AP	645	398
• AR	645	398
• GL	645	398
• Inventory	645	398
• Payroll	645	398
• POE	645	398
• POS	645	398
• SOE	645	398
Sorcim		
ACT 65	175	126
ACT 68	175	126
ACT 69	175	126
ACT 80	175	126
ACT 86/88	175	126
Pascal/M-80	395	284
Pascal/M-86/88	495	356
Supercalc	195	129
Supercalc 2	295	179
Superspellguard	195	129
Superwriter	295	185
Trans 86	175	126
Southwestern		
Z-Term†	100	75
Z-Term Professional†	150	109
Supersoft		
Ada Compiler	300	225
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C Compiler	250	188
Disk Doctor	100	75
Dungeon Master	40	30
Nemesis	45	34
Scratchpad	295	221
T/Maker Co.		
T/Maker III	275	215
Woolf Software Systems		
Move It	125	83

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dBASE II w/User's Guide [5]	729	419
Digital Research		
Pascal MT + 86 w/SPP-86	800	600
XLT 86	150	132
Woolf		
Move It	150	99

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Daisywriter		
Printer [10]	1395	1235
Hayes		
Chronograph [5]	249	199
Smartmodem 1200 [5]	699	509
Smartmodem 300 [5]	279	209
NEC		
3530 Spinwriter [10]	2190	1735
7710 Spinwriter [10]	3085	2295
8023 Dot Matrix [10]	695	495
Monitor 12″ Green Hi. Res [10]	285	167
Novation		
J Cat	149	119
Smart Cat 103 [4]	259	207
Smart Cat 103/212 [4]	595	476
Quadram		
Microfazer	189	160
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• In-line parallel	225	185

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most complex constructions without error or complaint. The company has shown steady progress in upgrading the product and adding preplanned enhancements. The documentation sets such a high standard of comprehensive excellence that others don't even come close. Only the function library is slightly lacking, and additional functions for sorting, randomizing, and ASCII/numerical conversion would be icing on the cake.

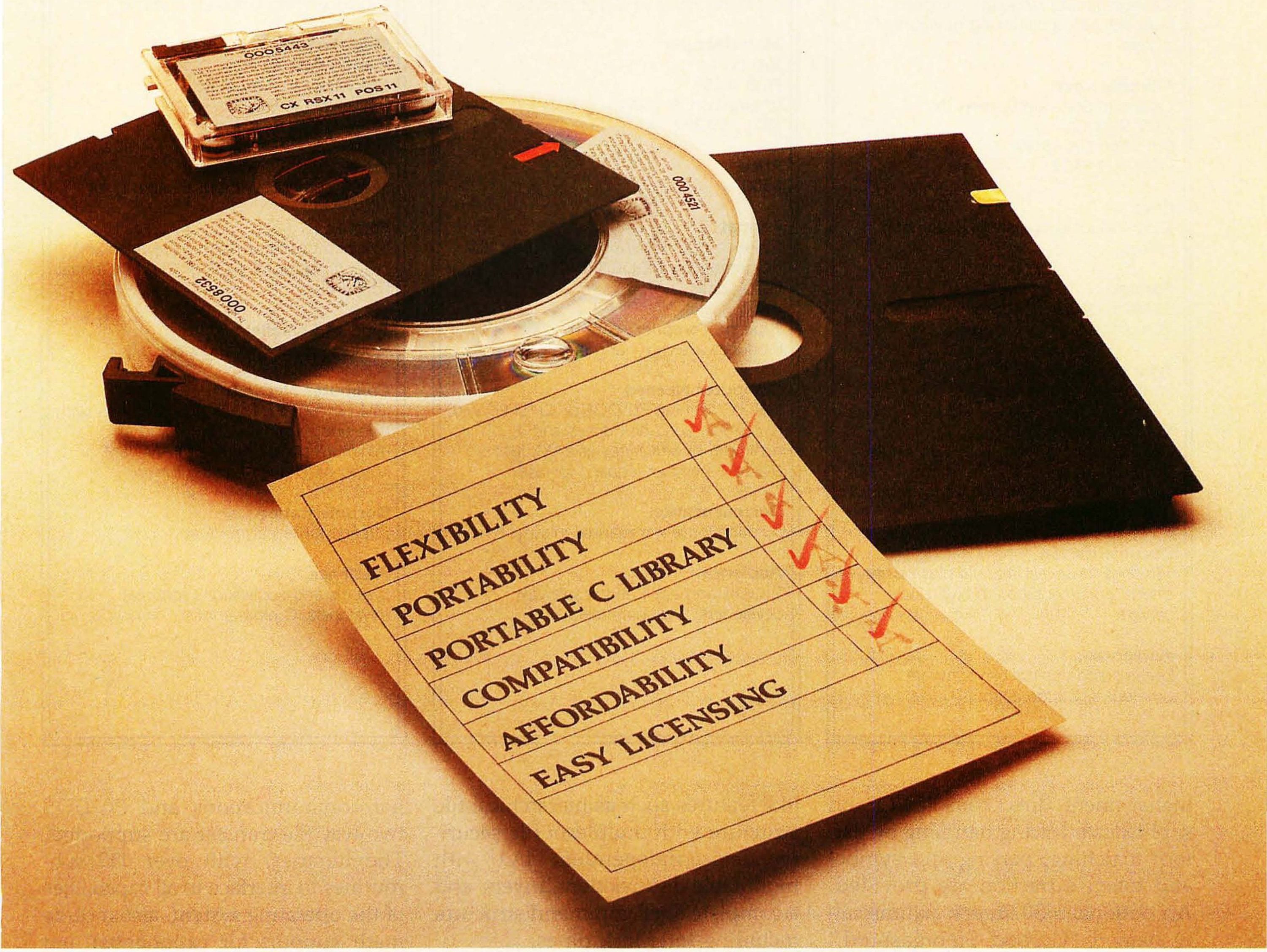
A full implementation of the C language, the Lattice compiler produces code only for the small memory model, although versions for the compact and big models are in use at test sites. A command-line option allows inline generation of 8087 floating-point code, but in the review compiler, library floating-point routines in 8087 format were substituted. Another command-line option enables you to intersperse C source code in the object module disassembler output, a step toward a planned high-level symbolic debugging package.

The few extensions to and variances from the C standard are worth noting. Only one copy of identically written string constants is generated by this compiler, although Kernighan and Ritchie state that all strings are distinct even when identical. Multiple character constants are allowed. Comments nest by default. Identical names may be used for members in different structures because the specific structure being referenced determines which member name (and corresponding offset and attributes) is intended.

The Lattice manual is logically organized and complete in its documentation of compiler libraries and assembly-language interface. The in-depth treatment of the relationship between the Lattice implementation and the C standard is especially welcome to the serious user. It lists variances and clarifications in order, with numerical reference to the corresponding section of the standard. The compiler's 90 error messages are fully and helpfully explained.

The object library includes additional functions for low-level memory

Compilers From Whitesmiths, Ltd. Are Earning Top Grades.



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Name
Quantum C compiler

Type of Software Package
C programming language compiler bundled with multitasking operating system

Manufacturer
Quantum Software Systems Inc.
7219 Shea Ct.
San Jose, CA 95139
(408) 629-9402

Price
$650 including operating system and utilities

Format
5¼-inch double-density single-sided IBM PC-compatible QNX format floppy disks

Type of Compiler
Produces assembly language

Computer Needed
IBM PC running QNX with two single-sided disk drives and a minimum of 128K bytes of RAM; 8087 coprocessor required for floating point

Documentation
186-page loose-leaf manual plus operating system documentation in two cloth binders

Audience
Systems and applications software developers, C programmers

Name
Supersoft C compiler version 1.1.3

Type of Software Package
C programming language compiler

Manufacturer
Supersoft Inc.
POB 1628
Champaign, IL 61820
(217) 359-2112

Price
$500

Format
5¼-inch double-density single-sided IBM PC-compatible PC-DOS or CP/M-86 format floppy disks

Type of Compiler
Produces assembly language

Computer Needed
IBM PC running PC-DOS or CP/M-86 with two single-sided disk drives and a minimum of 64K bytes of RAM; IBM Macro Assembler required for use

Documentation
80-page loose-leaf manual in vinyl binder

Audience
Systems and applications software developers, C programmers

Name
Telecon Systems C version 2.6

Type of Software Package
C programming language compiler

Manufacturer
Telecon Systems
1155 Meridian Ave., Suite 218
San Jose, CA 95125
(408) 275-1659

Price
$200—compiler without floating point

Format
5¼-inch double-density single-sided IBM PC-compatible PC-DOS or CP/M-86 format floppy disks

Type of Compiler
Produces assembly language

Computer Needed
IBM PC running PC-DOS or CP/M-86 with two single-sided disk drives and a minimum of 96K bytes of RAM; IBM Macro Assembler required for use

Documentation
21-page loose-leaf manual

Audience
Systems and applications software developers, C programmers

management, direct console I/O, and sophisticated string handling by pattern matching, parsing and symbol and token extraction are provided. An optional $150 library, whimsically named "C Food Smorgasbord," provides a complete fixed and floating-point BCD (binary-coded decimal) arithmetic package with 16 significant-digit accuracy, an extensive series of direct device I/O routines, and a terminal-independence package providing the programmer with access to a variety of predefined existing terminals using ANSI X3.64 standard conventions. Built-in facilities let you add new terminals.

Quantum C, nearly a full Unix version 7 standard compiler, is an integral part of a complete multitasking operating system that supports up to 16 users and 250 simultaneous tasks and includes a large number of Unix-like features such as hierarchical file structure with multilevel file security, device-independent I/O with mountable disk-resident drivers, and a complete shell command structure including inter-task pipes.

Quantum C has far too many special features and programs to explain in this article. One highly innovative feature worth mentioning, however, is that it shares the last three stages of code generation and assembly with optional FORTRAN 77, PC-compatible BASIC, and extended Pascal compilers, allowing separate compilation and cross-linking of modules from any of these different languages into one executable file. The four languages share a single extensive series of subroutine libraries; all require the 8087 coprocessor for floating-point calculations and all employ the same assembler (which may be used separately) and linking loader. Full external communications and PC-DOS two-way file transfer are supported. The libraries, with over 150 subroutines to interface to all capabilities of the operating system, also include math support for exponential and logarithmic functions and trigonometrics, including hyperbolics and inverses.

The C compiler supports enumerated data types and allows in-line assembly language insertion via the #asm directive. It does not currently support initialization of auto variables, bit fields, or expressions following #if. Structures are initialized as if they were int arrays, and braces may not be nested in initializations. All of these features will be supported in the next major release.

All Quantum parsers support 64 significant characters in variable names. I/O redirection is supplied by the underlying operating system and thus is available to all programs in all

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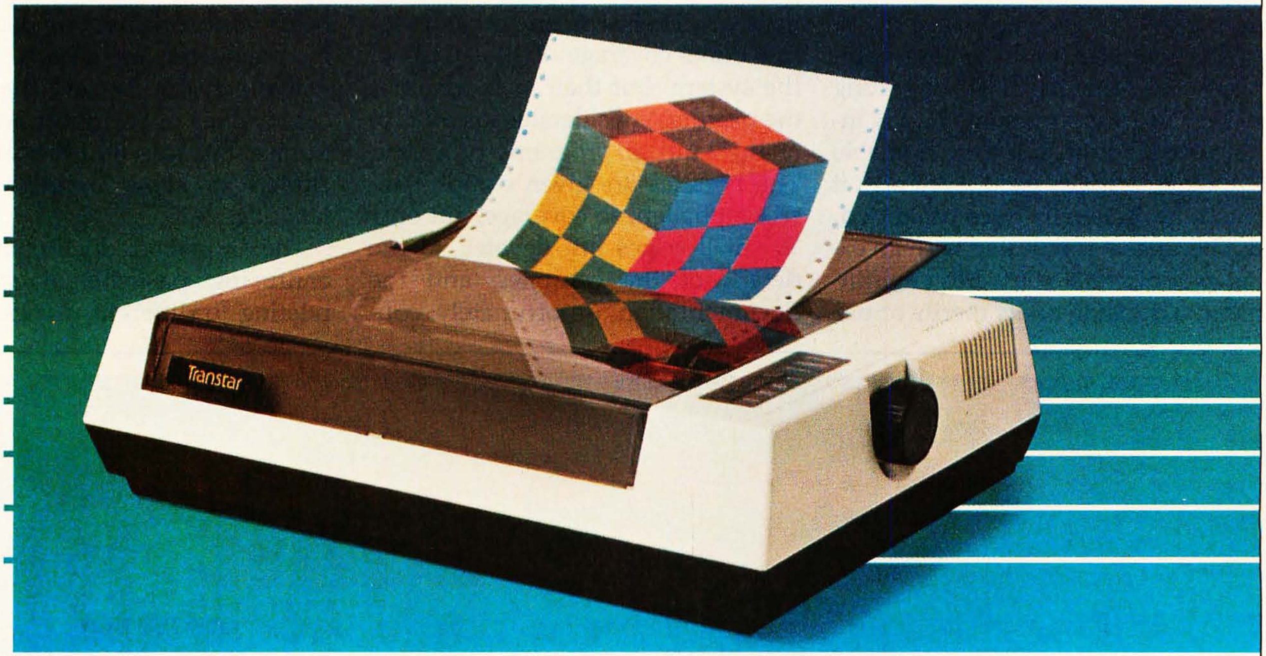

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languages. Kernel interface is possible on two levels, by software interrupts or message passing. Memory allocation is according to a system-specific model, with an initial configuration, similar to the small model, defaulting to a low-memory code segment with the remaining two allocatable segments concatenated immediately above. Direct segment-register usage manipulation by the programmer is allowed. In addition, the C parser recognizes the @ symbol as a pointer reference in the same manner as * pointers but as a reference off the base value of the ES segment register rather than the DS register used in normal C pointer reference.

This compiler produces fast, compact code for its host operating system and supports some highly innovative features. If it were available for more widely used systems, it could be generally recommended, but because it is bundled with an extensive discrete software environment, a decision on its merits or use must be based on the entire operating system, not just the compiler alone. While I like the Quantum development environment—especially on a hard disk where command file access is reasonably short—full evaluation of this system is impossible here. It is worth noting that, while the system contains many powerful commands, programs, and utilities, the user pays a considerable price, in terms of performance, for the multitasking and multiuser capabilities. Potential users should anticipate some actual need for these capabilities.

The operating system and C compiler are accompanied by two manuals. Their structure provides for functional coverage of all aspects of the system, but their style assumes the user has considerable knowledge of the kind of programs provided. The libraries are given comprehensive alphabetized coverage, but only 16 small pages are devoted to the details of the compiler, and the documentation unfortunately contains no indexes.

Supersoft C is one of a related series of products said to be available for any host-target combination from 8080, Z80, 8086, and Z8000 microprocessor families. Current operating systems supported are said to include the versions of CP/M and MP/M for both the 8080 and 8086 processors, MS-DOS, Unix, Xenix, and Central Data's ZMOS. The subroutine library is supplied in both source and object forms, and the package contains five sample programs.

In relation to the standard, the Supersoft implementation lacks long, double, and float data types, static and typedef storage class specifiers, bit-fields, and initializers on declaration. No parameters are allowed to #define macroinstructions, and the preprocessor does not support any conditionals, but #asm and #endasm are included to allow in-line assembly language.

The Supersoft documentation, a confusing pastiche of fragments relating to different processors and

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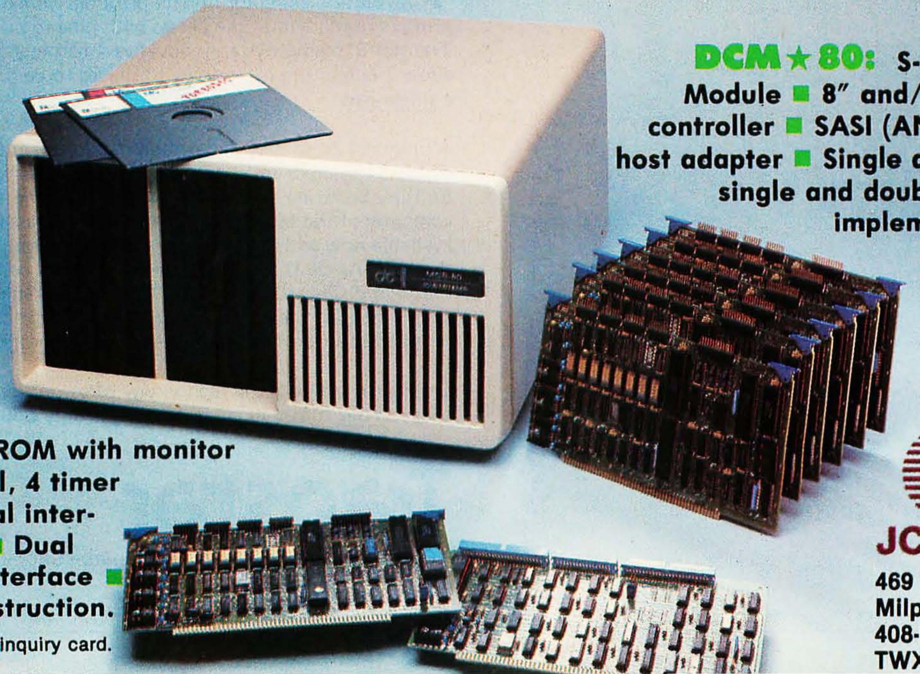

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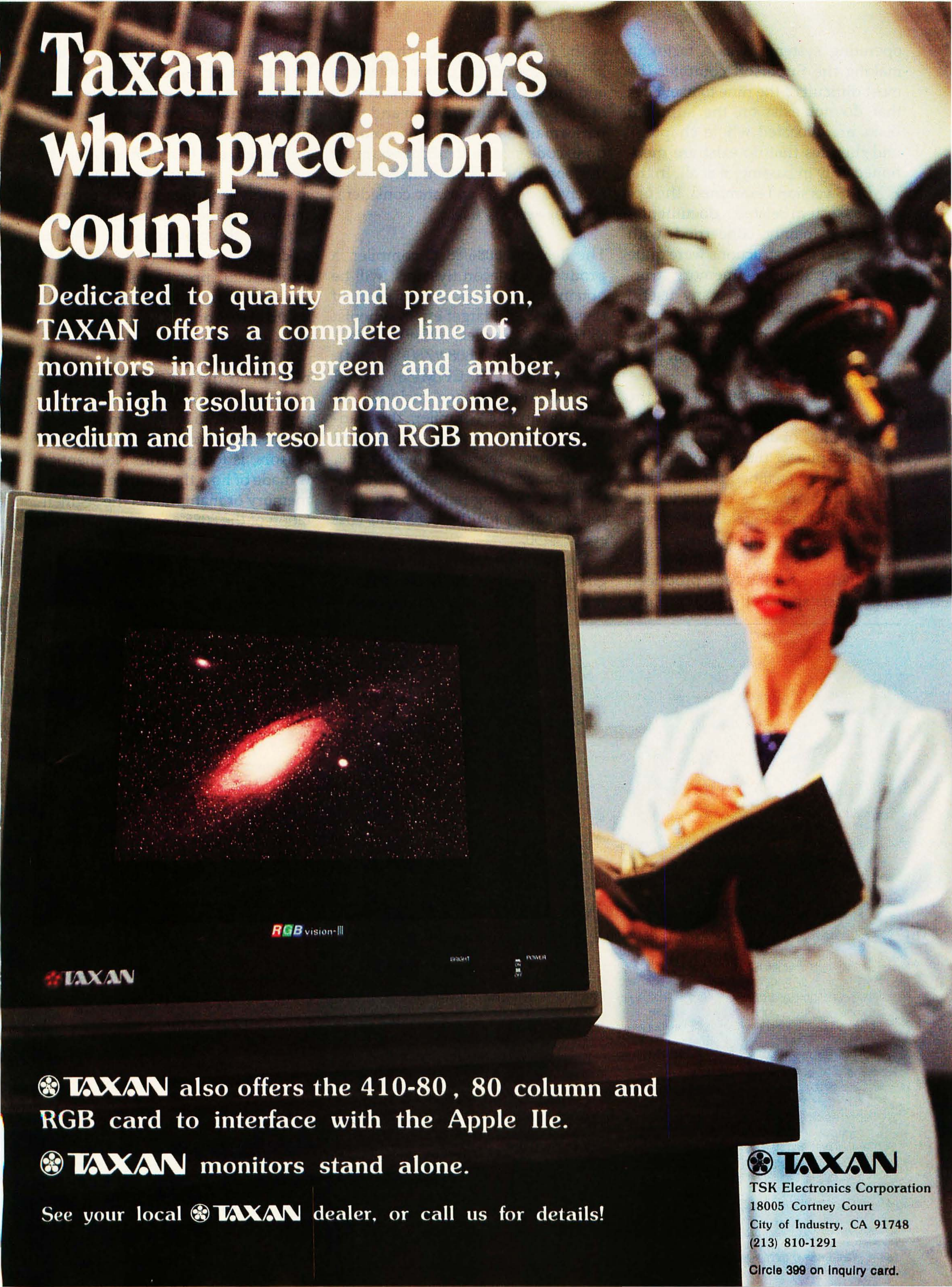
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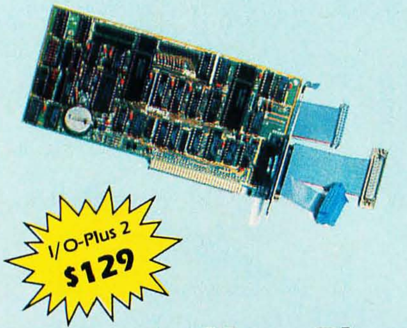
operating systems, was a factor in making the Supersoft compiler the most difficult of the nine to use. Files that do not exist on the supplied disks are allocated whole chapters, and the files that do exist are mentioned only in passing, if at all. In the PC-DOS version I examined, the operating-system-related documentation was mainly concerned with CP/M, and its instructions were quite misleading. Run-time memory structure was only one of many useful items the manual neglected to cover, although an examination of the compiler's output shows the default to be the small model.

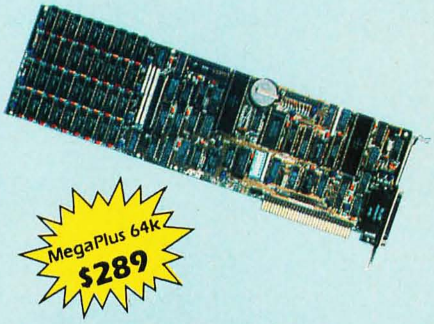
This software consistently took the longest time to compile the largest executable files of any compiler evaluated. In spite of the size of the executable file, facilities for run-time I/O redirection were not included. The run-time package did, however, produce a copyright message each time the user's program executed. Execution times for the code produced were consistently in the bottom third of the nine compilers, with particularly poor results in pointer intensive and integer math operations. In light of the poor documentation and poor performance in terms of compile time, code size, and execution times, the software and documentation I received do not warrant consideration for serious use.

The **Telecon 8086/88 C** compiler, a product of Telecon Systems, will be obtainable for any combination of these host and target environments: 6809 (Flex, Uniflex, OS-9), PDP-11 (RT-11, RSX-11), 8080/Z80 (CP/M), 8086/88 (PC-DOS, CP/M-86). Priced at $200, the package includes, in addition to the compiler, the standard I/O library in both source and object form, the stdio.h header file, and 21 pages of loose-leaf documentation. A floating-point library (not yet available) for the 8088 will cost about $150.

The compiler accepts the full C language, and while the manual claims full Unix version 7 compatibility, potential users should note the lack of support for enumerated data typing and structure assignment. Register declarations are treated as if they are automatic. Compiler I/O can be redirected, and C source code may be optionally interspersed with the assembly-language output as comments. Other command-line switches allow the generation of absolute addressed output (the default is relocatable), preprocessor macroinstruction expansion only, or run-to-locate errors only. The compiler's 36 error messages are cryptic.

Documentation is sparse, and, in relation to the other compilers, incomplete. The description of interfacing methods to external routines, in an attempt to cover all supported processors, is too general. No mention is made of how the compiler allocates memory or manipulates the segmentation of the 8088 processor, although code examination reveals that the compiler supports the small memory model as default. Custom-segmentation schemes can be implemented





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STANDARD UNIX SYSTEM CALLS REPLACED BY C LIBRARY SUBROUTNES

	c-systems	Caprock	CI-C86	DeSmet	Intellect	Lattice	Quantum	Supersoft	Telecon
brk								X	
close	X		X	X		X		X	
creat	X		X	X		X		X	
__exit			X			X			
exit	X	X	X	X		X	X	X	X
lseek	X		X	X		X			
open	X		X	X		X		X	
read	X		X	X		X		X	
sbrk	X		X			X		X	
tell	X		X						
unlink	X		X	X		X		X	
write	X		X	X		X		X	

STANDARD C LIBRARY SUBROUTINES

	c-systems	Caprock	CI-C86	DeSmet	Intellect	Lattice	Quantum	Supersoft	Telecon
abort			X				X		
abs						X	X	X	
atof			X				X		
atoi	X		X				X	X	
atol							X		
calloc			X	X		X	X		
free			X	X		X		X	
longjmp									
malloc			X	X		X	X		
qsort			X						
rand				X			X	X	
realloc			X	X			X		
setjmp									
srand				X				X	

STANDARD C LIBRARY STRING FUNCTION SUBROUTINES

	c-systems	Caprock	CI-C86	DeSmet	Intellect	Lattice	Quantum	Supersoft	Telecon
strcat	X		X			X	X	X	X
strcmp	X		X			X	X	X	X
strcpy	X		X	X	X	X			X
strlen	X		X			X	X	X	
strncat			X					X	
strncmp			X						
strncpy			X					X	
index			X					X	
rindex			X					X	

Table 3: *Standard library functions included with each of the compilers. In the table, an X indicates the function is available, an ! (exclamation point) means the function varies significantly from the standard, and a blank means the function is not included. Most compilers also include additional, nonstandard functions.*

using assembly language.

The entire Telecon object library is entered to the linker in line with the user's program, rather than as a library to be searched through for only the appropriate code. Although this strategy ensures a consistent method across the range of processors supported, these files mean an additional 6K bytes at the least to any program. Fortunately, the source code is included, so the experienced programmer can separate what will be used from the remainder and recompile for minimum program size. Unfortunately, the library contains only a bare minimum of subroutines.

The Telecon compiler is simple and straightforward to use. Compile and link times in both memory disk emulator and floppy-disk environments were somewhat longer than the median, and incremental code size and execution speed were only average. For some reason, this compiler crashed when attempting to compile a function consisting solely of an empty for loop, used to factor out looping times from measures of other compiler performance facets, forcing the system to be reloaded. The Telecon compiler is relatively efficient at function calling, but it ranked behind the others in integer math, local-variable access, and pointer operations. I haven't seen or used the

STANDARD C LIBRARY CTYPE CHARACTER MACROS

	c-systems	Caprock	CI-C86	DeSmet	Intellect	Lattice	Quantum	Supersoft	Telecon
isalnum	X		X			X		X	
isalpha	X		X	X		X	X	X	
isascii			X			X		X	
iscntrl			X			X		X	
isdigit	X		X	X		X	X	X	
islower	X		X	X		X	X	X	
isprint			X			X		X	
ispunct			X			X		X	
isspace	X		X	X		X	X	X	
isupper	X		X	X		X	X	X	
*tolower	X		X	X		X	X	X	
*toupper	X		X	X		X	X	X	

*Conversion functions

STANDARD C LIBRARY stdio SUBROUTINES

	c-systems	Caprock	CI-C86	DeSmet	Intellect	Lattice	Quantum	Supersoft	Telecon
fflush	X		X			X	X	X	
fclose	X	X	X		X	X	X	X	X
feof						X	X		
ferror			X			X			
clearerr			X			X			
fileno						X			
fopen	X	X	X	X	!X	X	X	X	X
freopen						X			X
fread			X						
fwrite			X						
fseek	X		X			X	X		
ftell	X		X			X			
rewind						X	X		
getc	X	X	X	X	X	X	X	X	X
getchar	X	!X	X	X	!X	X	X	X	
fgetc			X			X			
getw	X		X	X				X	
gets	X	!X		X	X	X	X	X	X
fgets	X		X	X		X	X	X	X
printf	X		X	X	X	X	X	X	X
fprintf	X		X	X		X	X	X	X
sprintf	X		X	X		X	X	X	X
putc	X	X	X	X	X	X	X	X	X
putchar	X	!X	X	X	!X	X	X	X	
fputc			X			X			
putw			X	X				X	
puts	X	!X	X	X	X	X	X	X	X
fputs	X		X	X	!X	X	X	X	X
scanf	X		X	X		X		X	X
fscanf	X		X	X		X		X	X
sscanf	X		X	X		X		X	X
ungetc	X		X			X	X	X	

other code generators or compilers in this series, but I think the main reason for choosing this software would be its cross-compilation facilities. Because the output is assembly language, small applications could always be hand optimized for speed and compaction.

Conclusions

Evaluating the nine compilers in several broad categories may shed light on their main strengths and weaknesses. Software floating point is supported by Computer Innovations, DeSmet, Lattice, and Quantum. Compilers that use the 8087 are Computer Innovations, DeSmet, and Quantum, with the Quantum compiling in-line code and others making function calls to library subroutines. C-systems allows use of more than 128K bytes of memory, although versions of several others that do so are imminent. Run-time library source code is included in systems from Caprock, Computer Innovations, Supersoft, and Telecon. Under PC-DOS, the c-systems, Caprock, Supersoft, and Telecon compilers require ownership of the IBM Macro Assembler. The compilers from Caprock, Intellect Associates, and Supersoft were unable to compile several programs in the test group. C-systems, Caprock, DeSmet,

Unix Version 7 Extensions to the C Language

The two significant Unix version 7 extensions to the C language—enumerated data types and structures as function arguments—need further elucidation because no readily available source of information about them exists. Because Kernighan and Ritchie's standard text made provisions for both of them, they are likely to be more widely used in the future.

Enumerated Data Types

This powerful extension, shared with the other ALGOL-derived languages—Pascal (as enumerated scalars), Ada, and Modula-2—allows the user to specify named, ordered, and sequential data sets. By default, each newly created set member is assigned, in sequence, an integer value, ascending from 0 in increments of 1. The keyword enum *is used to define the new data type, declare the set members, and initialize those members to specific values. For example, to specify a sequential set of constants that may appear anywhere an integer constant is allowed,*

```
enum direction { north, east, south, west };
enum opcode { clc, stc, cli, sti, cld, std };
enum workday { monday, tuesday,
   wednesday, thursday, friday };
```

Constant integral values may be assigned, at declaration or later, to any of the set elements as:

```
enum direction { north = 'N', east = 90,
   south = 180, west = 270 };
```

If any set member is assigned a value, the remaining members progress from there. In the 8088 instruction set, for example:

```
enum opcode { clc = '0xf8', stc, cli, sti, cld,
   std };
```

Having previously defined the data type workday, *it can then be used in a declaration such as:*

```
enum workday today; /* today can have one
   of five possible values */
today = tuesday; /* assigns a set
   element to the new variable*/
```

An example of illegal assignment:

```
today = south; /* south is not one of the
   five valid choices */
```

The possible applications of this technique are extensive and can lead to dramatic improvement in the clarity and readability of C programs.

Structures as Function Arguments

Function calling with a structure as an argument causes a copy of the entire structure to be passed to the function. Similarly, with functions returning structures, a copy of the entire structure is passed back to the caller. This extension allows normally global data to assume a temporarily local nature, thus optionally isolating the actions of a function or series of functions on a structure.

For example, if struct1 *has been declared a structure, then* &struct1 *is a pointer to it. Calling a function with a pointer to a structure has been the usual way of passing this data type as a parameter. It looks like this:*

```
function(&struct1);
```

In compilers that implement the new version 7 extensions, to actually pass the entire data structure, rather than pass a pointer to the structure's location in memory, simply omit the &:

```
function(struct1);
```

Some compilers accept the structure name without & while still passing only a pointer, and they may or may not give a warning message telling what's going on. Obviously this can lead to trouble if you then transport that code into a true Unix version 7 environment.

Quantum, and Supersoft provide support for mixing in-line assembly language with C code. The Computer Innovations and Lattice compilers provide command-line options to ease translation from 8080 C source code written for the ubiquitous BDS C compiler, in which all variables are extern or auto.

Three broad classes emerged in performance, price, and user interface. At the top, "superior quality, but expensive and unsuited to the beginner" are the Lattice and Quantum compilers. Just below this category is software that offers particular individual values and features. These might be called "good-quality." In this category I would include the c-systems, Computer Innovations, DeSmet, and Telecon software. The last category, "other," includes Caprock, Intellect Associates, and Supersoft.

My personal preferences are Lattice C in the top category for its quick compile and execution times, small incremental code, best documentation and consistent reliability; DeSmet in the good category for its combination of fast compiling and executing code, good documentation, extraordinary price/performance ratio and many included utilities; and Caprock in the third category because it's a good learning tool for a reasonable price. C-systems, in the "good" group, is also attractive for its innovative debugger, PL/M compatibility mode, and memory-usage extensions. The company has been working hard to improve its product since it was released, and I would expect performance upgrading following the completion of their implementation. The DeSmet compiler would be rated at the top except for preprocessor problems and the newness of the producer, making the extent of future support and improvements unpredictable.

These nine C compilers are part of the largest array of compilation tools available for any single programming language on the IBM PC.■

Ralph A. Phraner (516 Shrader St., San Francisco, CA 94117) is an independent microcomputer product-development consultant currrently working with the C and FORTH programming languages.

Acknowledgments

I'd like to thank the compiler manufacturers who made their products available for my evaluation and those compiler authors who freely shared their insights and experience with me.

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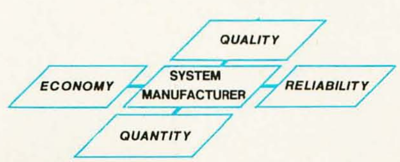

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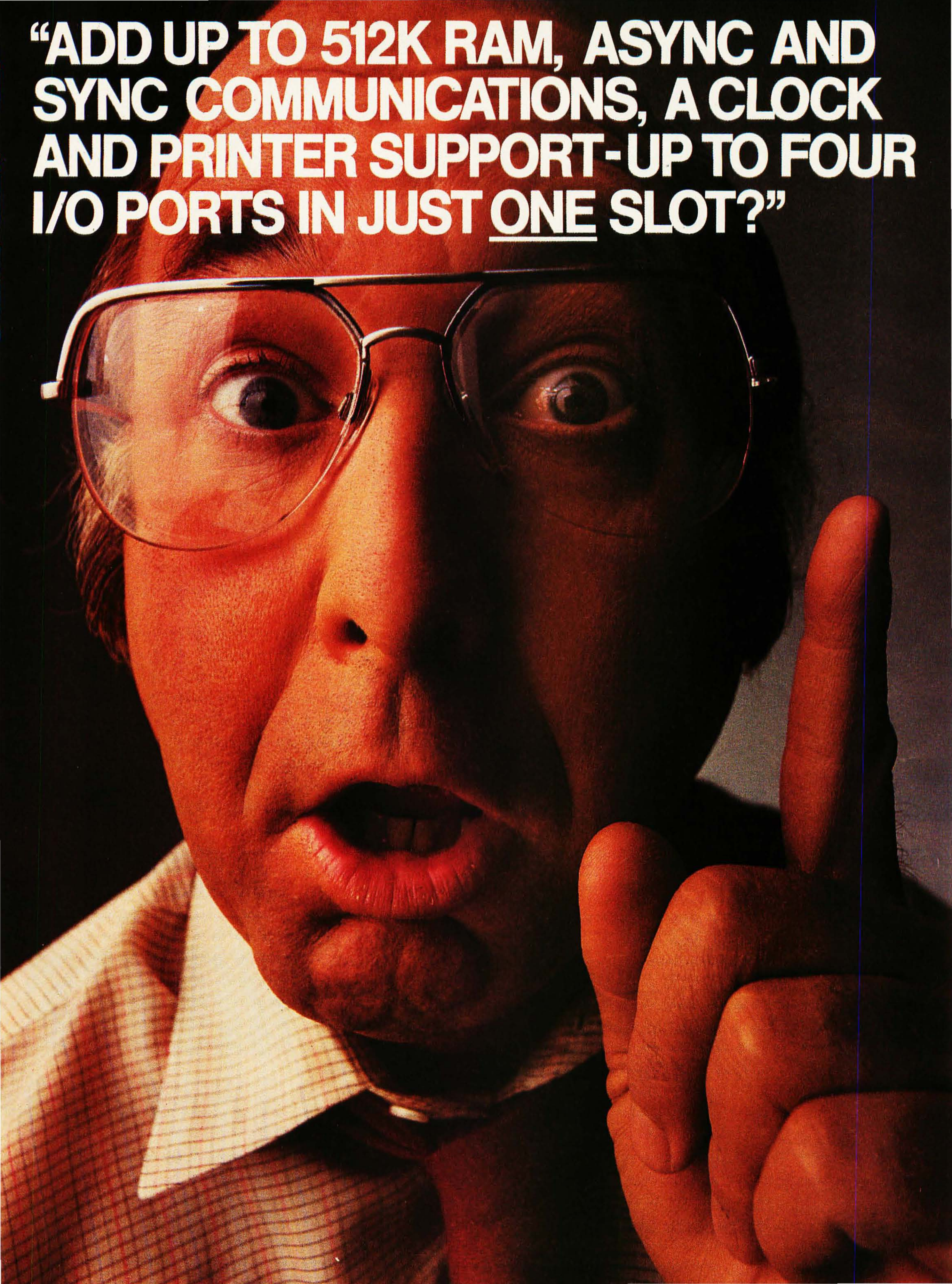
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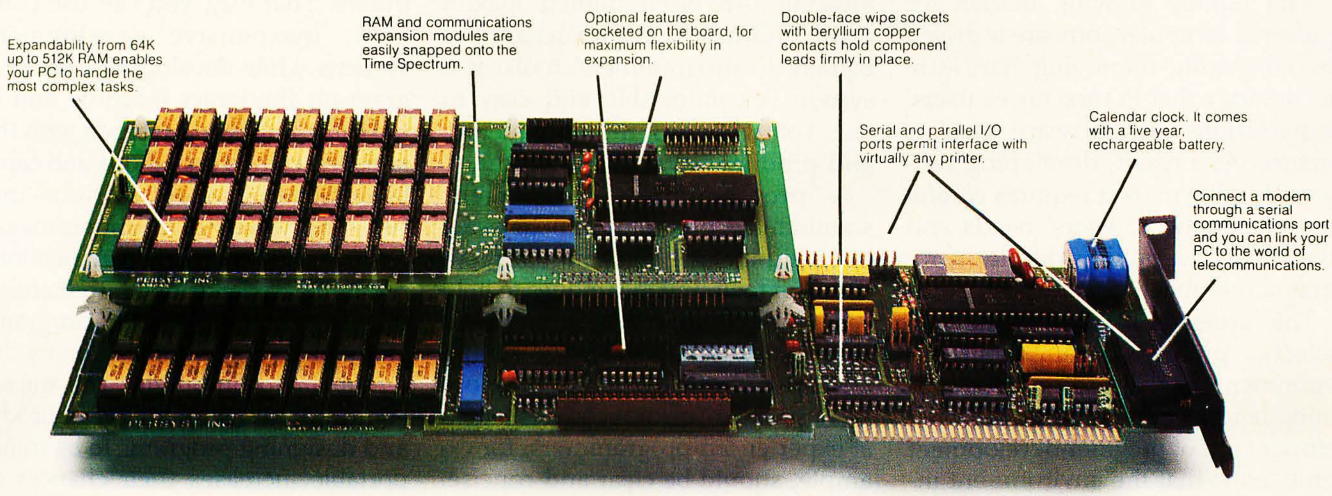

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Managing Software Development with C

Selecting a program-development environment that meets its users' needs

by Jason Linhart

Designing software for the rapidly changing personal computer marketplace is a complex task. But by carefully selecting a program-development environment, you can ease the job considerably. Choosing the development environment's major component, the programming language, from the many languages available today is difficult, but coming to grips with this problem early in the design cycle hastens the development of efficient, competitive programs.

The rapidly growing market for personal computer software is driven by constantly improving hardware technology that in turn raises users' expectations of software performance. As a result, developing software for this market requires careful understanding of users' needs and the ability to rapidly develop programs that meet these expectations.

This article will focus on how to select a program-development environment and choose a programming language that allows the most efficient use of program-development time. Note that the environment includes all the hardware and software tools used in the process of developing programs: the programming language, the compiler, the text editor you use to compose programs, and the machine you use for development. The development environment also includes such factors as programming style and the availability of consultants.

Choosing an Environment

A good programming environment can affect programming ease and code quality more than you might imagine. An often quoted maxim about end-user applications applies equally to programmers' tools: if a system is comfortable and easy to use, you will use it more frequently and produce better work with it.

A programming environment should make programs easy to write; it should include a large assortment of useful tools and techniques to help ease the programming process at every step. And the tools should never be obstacles to the development process—error messages aimed at experienced programmers, for example, should be clear and concise.

A poor programming-environment selection can limit marketing possibilities for the program. For example, licensing restrictions on the use of the development compiler's run-time library can prevent programs from being competitive with similar programs written on different systems. In general, environments aimed at producing programs for sale must not impose such disadvantages.

When you choose your programming environment, keep in mind that the development software should run on a variety of microcomputers. That way, you can use common, inexpensive development systems while developing your program on the target machine and at the same time keep in touch with the target machine's limitations and capabilities. Development software that runs on a variety of machines makes writing transportable applications programs easier. Indeed, to increase market potential, such programs should be transportable to many different microcomputers. The microcomputer industry changes quickly, and designing programs to be transportable increases their chances of running on the new hardware that

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will probably replace existing machines within three years.

A development environment should also be suitable for writing programs that are large, at least by microcomputer standards. Most systems won't constantly be used to generate programs with thousands or tens of thousands of lines, but an environment suited to such tasks is almost always adequate for writing small programs.

Choosing a Language

Selecting a programming language is the most fundamental step in the implementation of a programming environment. It is far simpler to change compilers, machines, text editors, or any of the other factors in the environment than it is to change the language in which a library of programs is written. The substantial investment in any code already written is lost if it must be translated into another language.

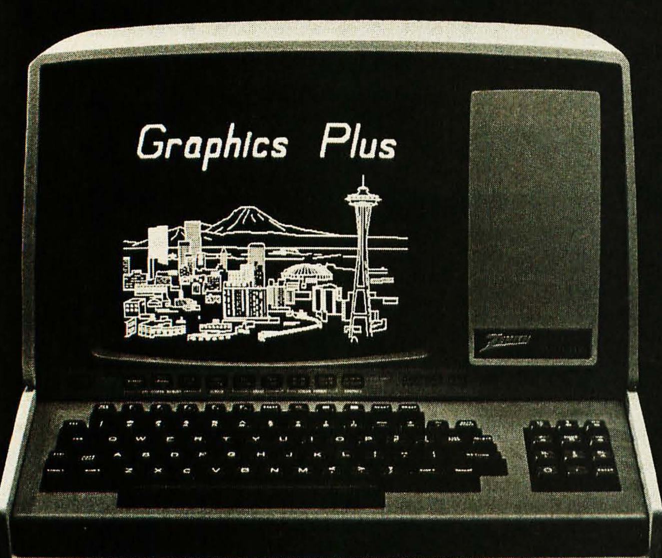
The first step in language selection is to choose between assembly language and high-level languages. Assembly language can be thought of as a more readable version of the binary machine code that tells the processor what to do. High-level languages let you program for an abstract or theoretical computer that does not necessarily correspond to any particular physical computer.

Assembly language tells the machine what to do for each program step. A program written in assembly language can therefore run as fast as the machine is theoretically capable of operating. In contrast, a program written in a high-level language must be translated into machine code, typically by a compiler. The result of this compilation is never as tailored to the machine as it would be if an experienced assembly-language programmer had written the code. Programming in assembly language always results in faster programs, given sufficient programming effort.

The size of the finished program is under the direct control of the assembly-language programmer. A compiler, on the other hand, translates a given program into a sequence of instructions that is not always the shortest possible route to the desired result. Because the programmer has no control over the compiler's translation operation, an assembly-language program can always be made smaller than a compiled program for a given task.

One major disadvantage of assembly-language programming is the large size of the source program. Assembly-language programs are 10 or more times larger in source-code form than their equivalent high-level language programs. High-level languages usually specify several machine instructions with a single statement, while an assembly-language statement specifies only one instruction.

Another drawback to programming in assembly language is that it generally introduces an additional level of complexity into the programming process. Assembly-language statements can often serve more than



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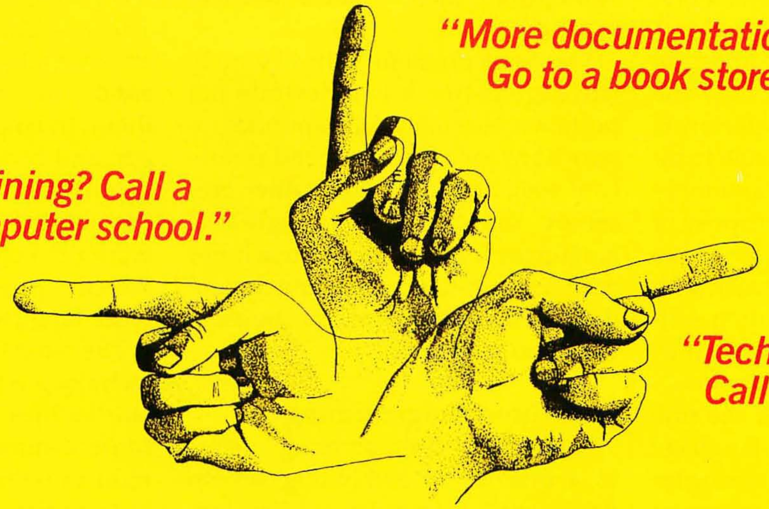

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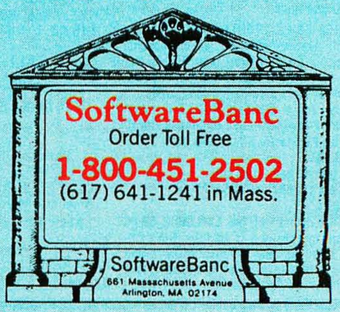

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one purpose, depending on the context. The original author of a program must select the proper assembly-language instructions to perform each task, and the person reading the program must understand how the sequence of instructions performs that task. It is usually advisable to include comments on each assembly statement to describe the purpose of the instruction. High-level language programs perform the same task with a single statement that is often self-documenting to some extent, so they generally require fewer comments.

Overall program size and the fine detail required in assembly-language programming on most machines have an important effect on programming effort. Some statistics collected by Frederick Brooks indicate that the time it takes to develop a program is proportional to the size of the source code and relatively independent of the level (high or low) of the language in which the program is written. Read Brooks' book, *The Mythical Man-Month: Essays on Software Engineering* (Addison-Wesley, 1975), for some fascinating, surprising, and still relevant facts, figures, and war stories.

The final problem with assembly language is that it is inherently not portable. Assembly code specifies instructions for a processor and is rarely, if ever, applicable to another processor. You can compile high-level languages for a variety of machines with a minimum of machine dependencies if you take care in choosing your compiler.

Structured Programming

"Structured programming" refers to a practice of combining several programming techniques. Any language selected should be suitable for use with structured-programming methods. Many modern languages have been designed specifically to support this method, and using one of them substantially eases the process.

The most basic structured-programming technique involves the use of control structure (program flow) built out of code blocks that each have a single entry and a single exit. These blocks can be built up of if-then-else-endif, while-do-endwhile, and do-until-end-do structures and others like them. In languages that contain only goto and conditional goto constructs, simulating these control structures is possible but generally requires more work than does using languages that directly provide the structures as basic language constructs.

The other fundamental structuring technique is the use of procedures or subroutines. These enable you to reuse common blocks of code, and, more important, they move the detail of complex operations away from local program flow, where such detail might be more confusing than helpful.

Along these lines, another important development-environment feature is separate compilation. Separate compilation allows a program to be made up of several source files compiled at different times and then linked together to create the final program. This technique enables you to split up the program into logical blocks developed at different times or by different people. Because each of these blocks can stand by itself, each may be tested separately, and a library of tested blocks of code can be developed.

Another helpful programming feature is support of data abstractions—groups of routines that define the structure and operations of user-defined data types by allowing them to be easily integrated into the language. Most languages inherently allow the manipulation of characters, integers, and floating-point numbers, but users often want to define new (at least to the language) abstractions—such as imaginary numbers, lists of items, and polynomials—preferably by adapting the program facilities that define the standard data types.

What Languages Are Available?

Thousands of programming languages have been invented, but only a few are widely available. Picking a language requires finding one that is

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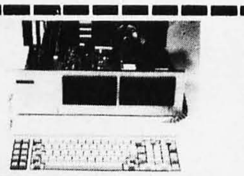

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The most popular languages on microcomputers have been BASIC and Pascal. FORTRAN, COBOL, and PL/I have been more popular on mainframes but are only just becoming available for microcomputers. Other languages such as C, LISP, APL, and FORTH have not yet or have only recently begun enjoying general popularity, having been used for the most part only by small, often specialized, groups.

From these languages, programmers must select the ones that are going to be predictably available for most or all existing machines and possible future machines. BASIC and Pascal, with their widespread popularity, can be expected to be available for some time. FORTRAN, COBOL, and PL/I are more complex languages that take longer to adapt to a microcomputer. Only recently have complete implementations of these languages existed for microcomputers, and some microcomputers are still not supported. LISP and APL are interesting languages that few people understand as yet. Both are very complex in their implementations and very powerful for programming, but unfortunately there is no reasonably complete implementation of either for any microcomputer. FORTH is a relatively young language that has many dialects. There does not appear to be a single standard implementation that interacts well with host operating systems (because FORTH is often thought of as an operating system in itself). C has gained a lot of popularity recently, and compilers for it have appeared for many microcomputers.

It is important to check for compatibility not only within a language but between machines and compilers. A standard for Pascal exists, but it is generally considered incomplete. Thus each compiler implementer adds additional features in incompatible ways. Because programming in the standard portion of Pascal is very hard, use of nonstandard extensions proliferates and can cause portability problems.

Despite its long life and popularity, there is no recognized standard for BASIC, although one is under development. Different implementations vary wildly from one another. One possible standard is Microsoft BASIC; unfortunately, there is no second source for Microsoft-compatible BASICs, and depending on a sole supplier seems unwise.

The standard for C is contained in Kernighan and Ritchie's book *The C Programming Language* (Prentice-Hall, 1978) and in the Unix C compiler. Both of these standards are complete and reasonably accurate descriptions of the language that compiler writers must adhere to with some care. Unfortunately, the C I/O (input/output) library is not standardized. The resulting problem is surmountable, however: because the I/O library contains nothing but C functions, a different I/O library can be substituted while maintaining portability.

BASIC, Pascal, or C?

The languages that appear to be consistently available on most micro-

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computers are BASIC, Pascal, and C. Other languages may be added to this list, but none of them is solidly available now. PL/I and FORTH, however, seem to be the most likely candidates for future support.

The speed and size of a compiled program are closely related. In almost all current compilers, smaller source code translates to fewer instructions and so takes less time to execute. Occasional exceptions to this rule exist, but for the most part small programs are fast. When you're writing programs for resale, size and speed are perhaps the most important qualifications of a compiler. For personal use a certain amount of waiting may be tolerable, but speed is often an important factor in program sales. The size of the code affects not only the size of the program as perceived by the user but the number of capabilities that can fit into the program.

Interpreted versions of any given language are slower than compiled code. Because of the importance of speed in influencing user impressions of a program, in the following summary we will consider only the compiled versions of each. A quick look at available compilers for each language shows that BASIC is noticeably slower than the others and that C usually is slightly faster than Pascal. C's performance is due to the fact that it was designed to be very easy to compile. The basic operators in C correspond to basic machine operations on many machines. Thus C can be compiled more closely to a specific machine than Pascal or BASIC, given the same amount of complexity in each compiler.

As mentioned, separate compilation is an important feature in the development environment. Neither BASIC nor Pascal offers separate compilation as a standard feature, although some implementations offer this capability. Note, however, that using separate compilation features that vary from one system to another causes portability problems. Separate compilation, a standard feature of C, is available in all implementations.

It's difficult to judge portability accurately. At present, no accepted standard for BASIC exists, and the standard for Pascal is considered very limiting and is almost always extended. The standardization process for Pascal is farther along than that for BASIC, but in neither case do the available compilers adhere closely to the standards. C has a well-defined standard, the version 7 Unix C compiler, which is also well documented in Kernighan and Ritchie's book. Almost all existing compilers adhere to the standard or provide a proper subset of it with no loss of language generality. Thus the portability of C programs is much higher than those written in BASIC or Pascal.

BASIC is the weakest language for structured programming. Most BASIC systems do not have named subroutines, local variables, do-until-enddo, while-do-endwhile, or record structures, to name a few limitations. Some of these features are being added to recent BASIC systems, but extensions are not being done consistently from one system to another. Pascal is much better because it provides almost all of the common structured-programming constructs. C also provides a full set of structured-programming features, and it has greater flexibility as well.

BASIC does not provide any facilities to support the use of data abstractions. It has a fixed set of data types and no facilities to define more. Pascal provides structures and pointers, both of which can be used to implement data abstractions but present limitations.

In Pascal, to define a data object and several procedures that act on it so that they can be used anywhere in the program, you must define all data and functions at the top level of the program. This means, first, that the structure of the source is forced on the programmer. Second, it means that the entire representation of the data is accessible to the entire program, making name conflicts and invalid data access very likely. Finally, the lack of separate compilation means that all of the code associated with a data abstraction must be inserted into the source for a particular program that uses it.

C is better suited to data abstractions. A data abstraction can be a

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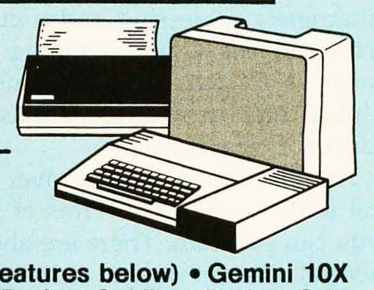

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single compilation unit in which only the desired function names are visible to the rest of the program. The data representation can be completely hidden within the single source file. Various modules can be maintained separately and linked together to form the final program. C does not provide type checking on these user-defined types—a limitation that is alternately a blessing and a curse. You can use a programming tool such as lint (so named because it "picks nits" in your programs) on Unix for type checking.

Another advantage of C over Pascal is its flexibility in terms of how you can program. There are always several different ways to code a given construct, and you can choose an appropriate one depending on the level of readability, speed, or programming style you want. You are not forced into a programming style by the language; you are free to explore the style suggested by the task at hand. This ability is most apparent when a particular section of the code must run very fast. C provides constructs such as pointers and register variables that can be used to locally improve the speed of a particular spot of code instead of depending on the overall quality of the compiler.

Picking a Compiler

Having picked a language, C in this case, we still have to pick a compiler. Several C compilers are available for each microprocessor, so we can pick the one that comes closest to meeting other design goals.

The first thing to check on a compiler is the accuracy and completeness of its implementation of standard C. It is not actually necessary that it implement the full language. The C programs should run on a large variety of compilers, so it is best to stay away from features that might be missing on some compilers. C has very few such features; most have to do with features added in Unix since the C book was written. Still, the compiler must implement most of the language accurately.

It is also important to check how long it takes the compiler to compile a large program. Because the compiler will run many times, long compilation times can be a problem. The difference in compiling time among the available compilers is *incredible*. I have observed compiling times for compilers working on the same medium-sized program vary from 40 seconds to 15 minutes.

The size and speed of the resulting code will affect every program you write for it every time it is run. People might be willing to wait around for the compiler, but it is hard to get them to buy a slow program. The size of the compiled code usually varies by a factor of up to 2 between compilers. Remember, a code-size improvement of just 1 percent in a medium-to-large program can make room for another feature. Fine differences are worth watching.■

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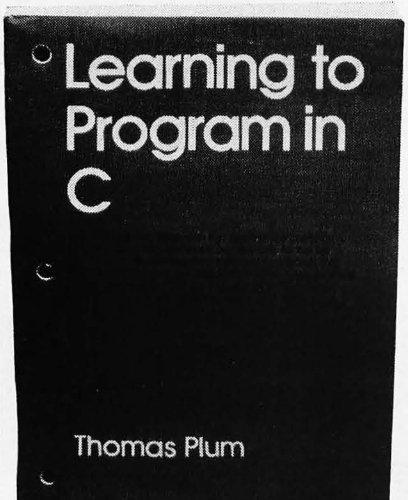

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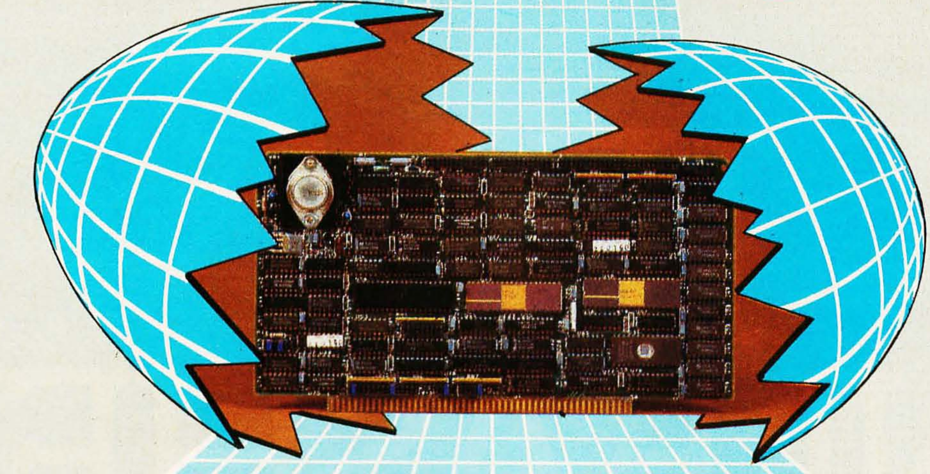

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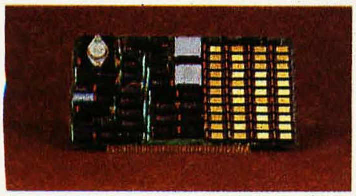

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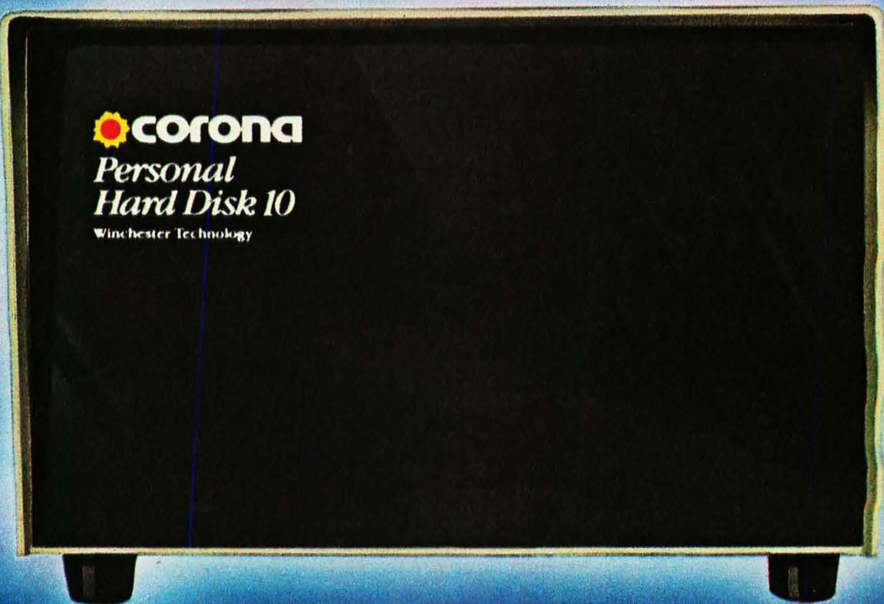

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The Unix Tutorial

Part 1: An Introduction to Features and Facilities

A look at some of the programming tools available to a Unix user

by David Fiedler

C. Unix. In the acronym-happy world of computers, these collections of letters stand out. The C language, it is whispered, can replace everything from assembly language to Pascal, and is only understandable by those willing to deal with a 5-year-old text and lots of squiggly characters; Unix, the legendary operating system from Bell Laboratories, is now being offered to the public under a half-dozen names and by four dozen computer manufacturers. Why are C and Unix always spoken of in the same breath, and why are so many people talking about them at all?

This three-part series will attempt to answer this and other questions about Unix and C. This month I'll present a tutorial overview of the Unix operating system and its toolbox of utilities, with explanations of its internal structure as well as its user interface.

In part 2 I'll discuss a few more Unix utilities and the variety of applications that have been written in or adapted to the Unix environment. Part 3 will focus on Unix implementation by different software vendors for several computers and how Unix compares to its competitors—Unix work-alikes, look-alikes, and the other 16- and 32-bit operating systems.

Unix was specifically designed to make software development easier.

The popularity of Unix is easily explained. It was the first complete programming environment designed by programmers to make it easier to write programs. (See the text box "The History of Unix.") Like the C language, it has both elegance and simplicity, and like most great discoveries, its virtues seem so obvious that you may wonder why no one thought of them before. (See figure 1 for a schematic breakdown of Unix's features.)

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The way you deal with files at the user level is particularly interesting. On many large timesharing computer systems and most home or

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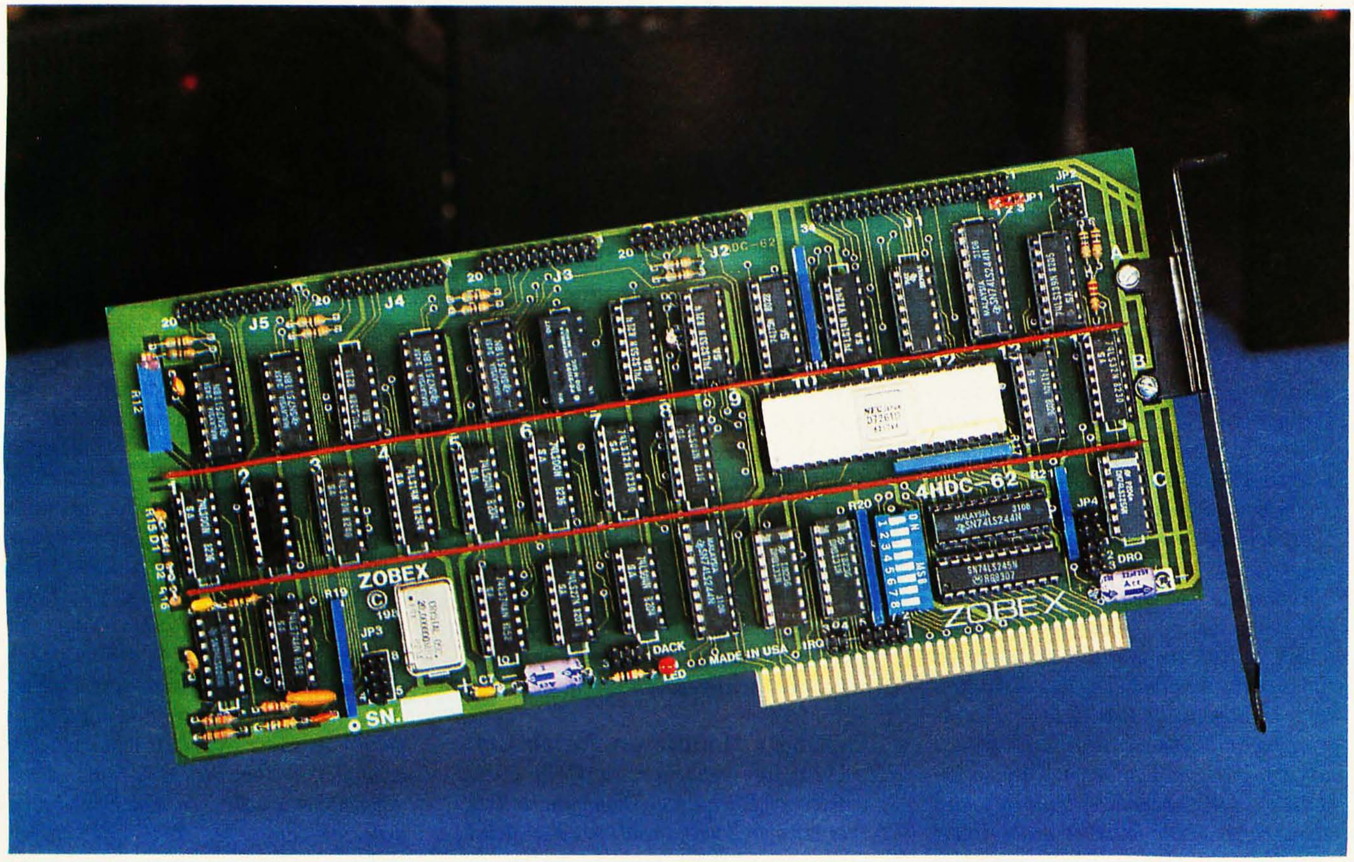

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The History of Unix

In the late 1960s, a project was underway at the Massachusetts Institute of Technology (MIT) to improve the state-of-the-art in timesharing software. Along with MIT, Bell Laboratories and General Electric (GE was once a mainframe computer manufacturer) were collaborators in the venture. But Multics, as the system was christened, was too big and slow—an overdesigned behemoth of the software world. So Bell Labs pulled their people out of the project, which left MIT and GE to develop the system further on their own. (They did, and Honeywell, who later bought GE's computer operation, still sells Multics.) Unfortunately, that left Ken Thompson, a computer scientist at Bell Labs, without any hardware to run his video game.

Thompson had written a simulation of the solar system, called Space Travel, which ran on the Multics system on a timesharing terminal. The loss of Multics was the impetus he needed to find hardware he could use exclusively. He gained access to a Digital Equipment Corporation (DEC) PDP-7, complete with a video display that would enhance Space Travel tremendously. While Thompson was rewriting Space Travel for the PDP-7, he began experimenting with some ideas he had for a new type of file system. Working in PDP-7 assembly language, he soon had his file system running with some utility programs and a central core (or kernel) that together made a rudimentary operating system. Here was a system designed by one man for the sole purpose of making his own software-development work easier. Unix was thought to be a good name for it—the Uni (one) was a word play on the Multi (many) of Multics.

Unix came to the attention of others at Bell Labs, including Dennis Ritchie, another systems software designer. Together, Ritchie and Thompson enhanced Unix, adding some word-processing facilities in response to hints that another department needed a word-processor. This earned the designers enough funding for a PDP-11 minicomputer, a more modern and reliable machine than the PDP-7. Eventually, other departments bought PDP-11s and chose to use Unix for the software base rather than DEC's own operating systems.

But Thompson, dissatisfied as he was with other operating systems, also felt that programming languages could be improved. FORTRAN was tried and discarded. He then worked for a while on BCPL (Basic Combined Programming Language), which was a simplification of CPL, itself a simplification of the Algol 60 language (today, we would call Algol 60 a Pascal-like language). Thompson condensed BCPL down to its most basic features. The interpreted language that resulted he named simply B. Ritchie then took the best parts of B, reworked them until he had a language that was simple and elegant, added data structures, and called it C. Ritchie and Thompson both felt this was a language suitable for systems programming—one that allowed a programmer to express concepts clearly without being tied to one machine's architecture, and yet was efficient enough so that assembly language would not be needed for speed.

Getting a Handle on Portability

Unix was rewritten in C in 1973, whereupon Ritchie and Thompson realized that because C was a relatively high-level language, compilers could be written on other computers to give them C capability too. And because Unix was written in C, theoretically Unix could then be moved to these other machines. The experiment was tried in 1977 with an Interdata 8/32, a 32-bit minicomputer that was as unlike the PDP-11 as possible. All code specific to the PDP-11 was taken out of the kernel and rewritten to make it easy to transport Unix. After the Interdata test, they moved Unix to an IBM/370 mainframe. With each trial they learned more about C, Unix, and portability in general.

Until Unix, operating systems were written exclusively in assembly language. This long, error-prone process seemed the only one appropriate to an industry that considered machine efficiency to be more essential than human efficiency because computers were more expensive in dollars and cents than human labor. Compared to other languages, assembly language allows the fastest execution of instructions and takes up the least memory space; therefore, programs as important as operating systems could only be written in assembly language. Who cared if a programmer or two went crazy trying to understand it? What was the difference if it took a long time to write and three times as long to debug?

Ritchie and Thompson saw that a software designer's environment was more important, in the long run, than that of the computer; computer hardware tends to get cheaper and faster, while the cost of labor in both economical and emotional terms tends to go up. This last is especially true when the software tools at hand are not appropriate for the job. Unix forever broke the notion that a system had to be written in assembly language and therefore tied to a specific computer design, word size, or architecture. For the first time, an entire programming environment, including file system, kernel, applications packages, utility programs, and user interface, could be moved to an entirely different type of machine.

Think about that for a moment. Look at the CP/M 2.2 operating system. CP/M has gained immense popularity; it runs on computers made by literally hundreds of different manufacturers and supports many different languages and applications packages. Why is it so popular with computer makers? CP/M is portable to many different hardware configurations. The catch is that the systems must use a microprocessor than runs 8080 assembly code.

In comparison, you can now run Unix or Unix-compatible systems on computers based on any of these processors: 8080, Z80, 8086, 8088, Z8000, 68000, 16032, LSI-11, PDP-11, VAX, HP-9000, Perkin-Elmer, Gould S.E.L., BBN C-Machine, IBM Series/1, and IBM/370. Typical hardware configurations range from $5000 to considerably more. A program correctly written in C for any of these machines will run on any other one, needing only to be physically moved and recompiled. No doubt you can see why so many software houses have suddenly discovered Unix. By using C and Unix, they can expand their potential customer base tremendously with little trouble—one user manual, one customer support group, one version of source code. The net result can benefit everyone with better, more widely used software at lower prices.

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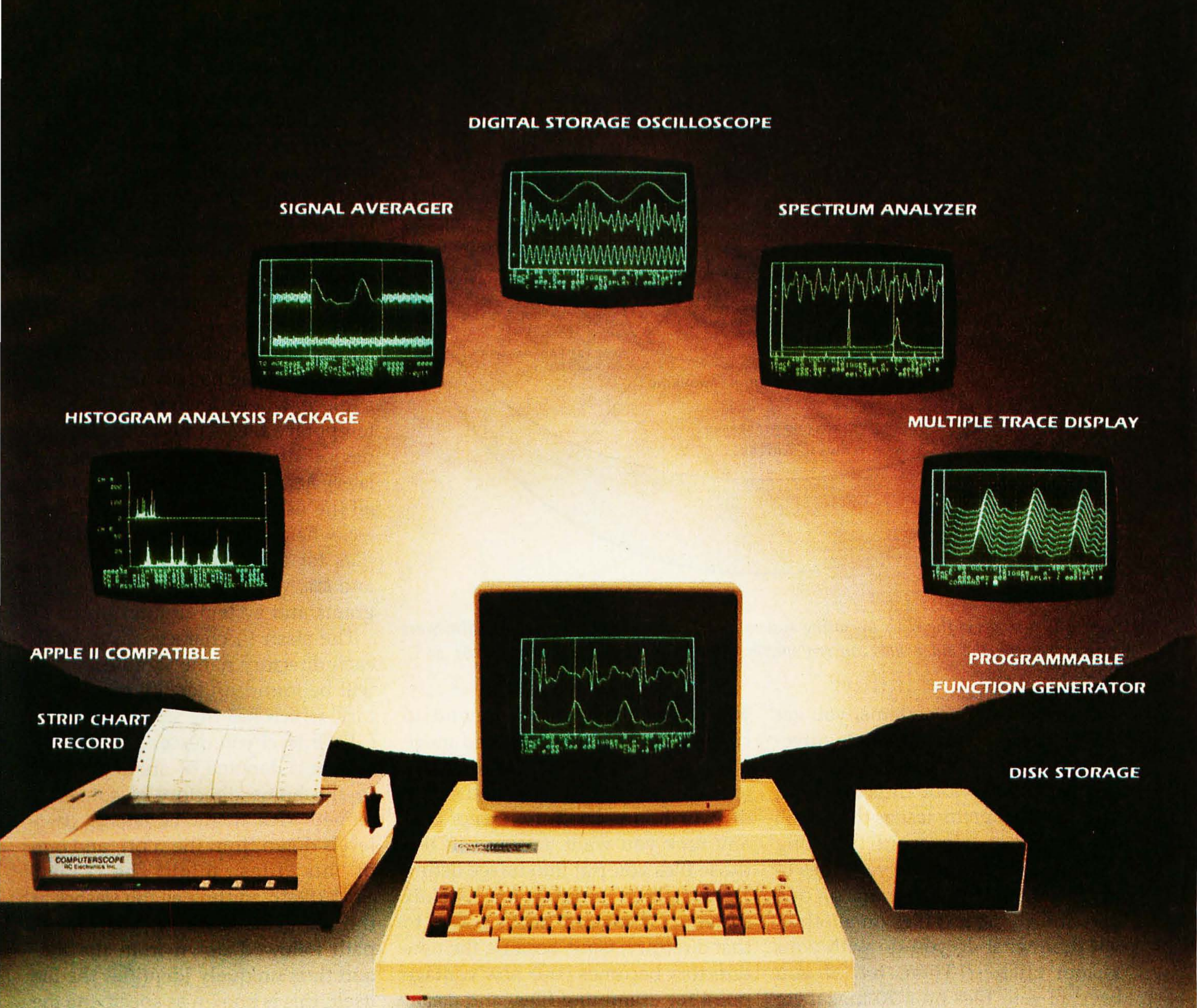

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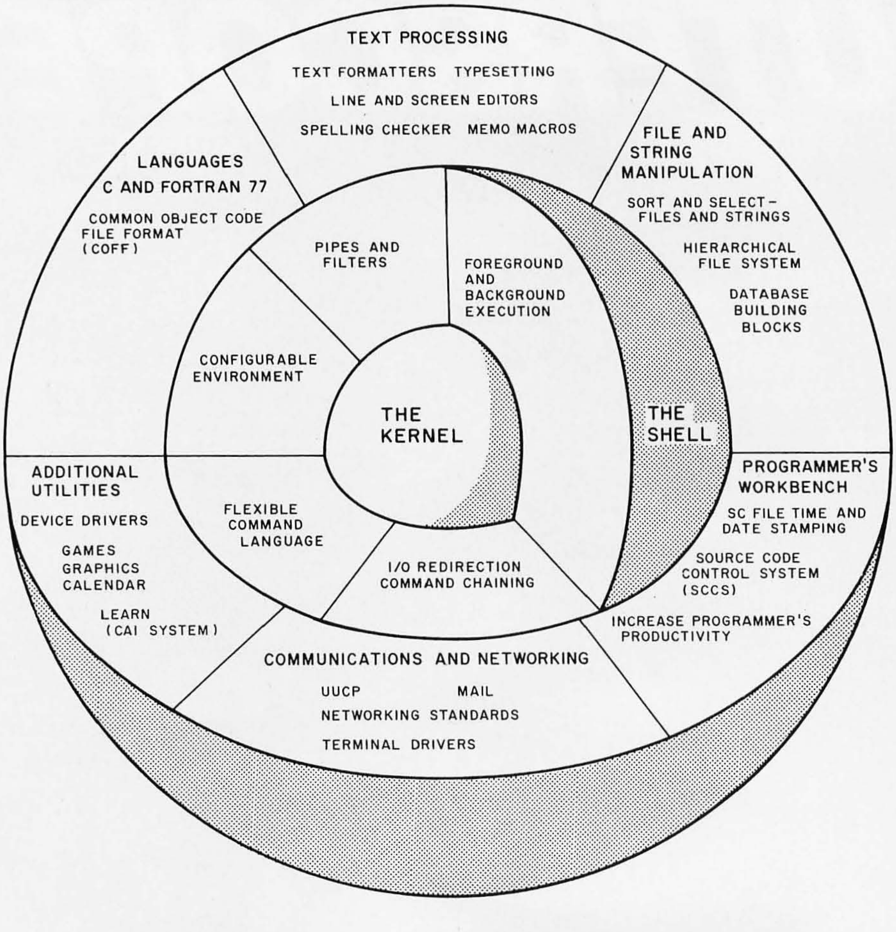

Figure 1: *A model of the Unix operating system and its components. The inner facilities are general purpose; the outer ones concern specific applications. (Figure courtesy of AT & T.)*

business computer systems, you get used to looking at your single directory (a collection of files). If you have, say, 142 files in your directory, you have to watch pretty fast as they scroll up the screen. To avoid this long scroll you might split up your files to have all the BASIC programs on one disk and all the text files on another, but then what do you do with your system utilities? Then, too, if you have all your files on a 20-megabyte hard disk, you might have to scroll through as many as 1375 files before you find the one you want. More troubles arise when you have two files with the same name and don't know which is the latest version. Now imagine 20 people using the system at once with all these problems.

Relax, you've got Unix. As a Unix user, you begin with a single directory, called your *home* directory. When you want to create a new grouping of files that belong together, you simply issue the command to create a new file directory and move those files into it. The new directory looks to you almost like another file in your home directory, except that any time you want to, you can use those files you put into it (see listing 1, a sample session on a Unix system). Or you can "move down" to that directory: *move,* because the new directory becomes your new vantage point for examining files, and *down,* because the new directory can be thought of as being below your home directory (see figure 2).

You can repeat this process any reasonable number of times by creating new subdirectories one level below your home directory or at deeper and deeper levels, or by branching out in both directions at once. The tree-like structure of files and directories on Unix enables you to group files as you please, so one directory never has to have too many files. Because each "branch" or new directory is logically distinct from all others, two files in different directories may have the same name without confusion.

Technically, the inverted tree structure is also called a *hierarchical* file system (it resembles a hierarchy or organization chart), and the directories don't actually contain any files, but rather contain pointers or *links* to the files by which the system can locate them. In fact, a directory is just another file that contains this link information, called the *i-node*. The highest directory shown in figure 2 is called the *root* directory, and it normally contains the executable kernel of Unix in binary form, as well as links to several important system directories, the names of which are almost always the same on all Unix systems. These usually include /tmp, a place where anyone may create temporary files as needed; /dev, the device directory (to be discussed later); /usr, in which files belonging to all the users of the system are kept; /etc, where special programs and data files for adminstration are located; and /bin, where most executable programs and system utilities reside.

The slash (/) character in front of each directory name signifies that it will be found under the root directory, which has the simple name of /. Each level you descend in the file system is denoted by another slash, so the home directory of someone named Rick might be /usr/rick (two levels down from the root), and one of his files might be called /usr/rick/test.c. Putting all the slashes in the file name identifies the unique path followed down from the root and thus uniquely identifies the file itself; this is known as specifying the *full path name*. If Rick logs onto the system, he finds himself in his home directory /usr/rick, from which the file test.c could be accessed simply as test.c, without having to specify the full path name.

Another interesting feature of the Unix file system design is its extensibility. It stands to reason that the /usr directory, under which all users keep their files, needs to have more storage space reserved for it than does the /tmp directory, which only holds files for a short period of time.

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Circle 282 on inquiry card.

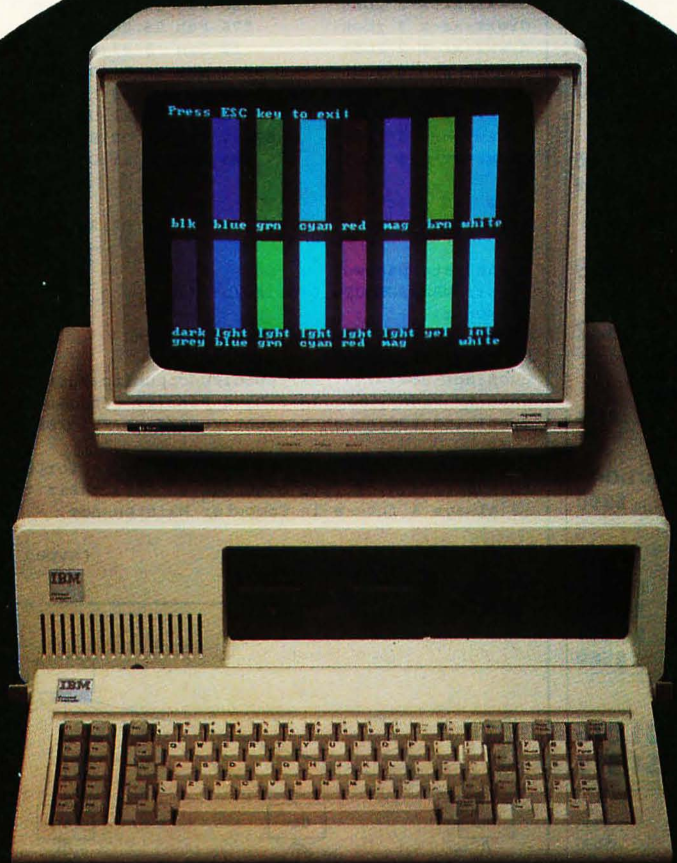
Circle 1 on inquiry card.

Listing 1: *A sample session on a Unix System with comments added. The $ is the Unix prompt.*

```
login: davg                                      (typing error)
Password:
Login incorrect                                  (login name not recognized)
login: dave
Password:
Last login: Wed Mar 30 18:46:57 on seriall

See /usr/news/READ_ME.                           (system message of the day to all users)

$ ls                                             (what files are in my home directory?)
bin         mbox       sieve.c   src             testl.c

$ who                                            (see what users are logged on the system)
dave      seriall Mar 30 18:46

$ df                                             (see how much space is left on disk)
/usr     (/dev/usr  ):     12045 blocks           8109 i-nodes
/        (/dev/root ):      8071 blocks           6666 i-nodes

$ time cc sieve.c                                (time the compilation of a benchmark)

real         36.0                                (actual elapsed time)
user          6.2                                (time spent executing the cc command)
sys           6.9                                (time spent in system getting files, etc.)

$ time a.out                                     (execute benchmark and time it too)

1899 primes
real          8.0
user          7.4
sys           0.4                                (this is small since the benchmark
                                                 program is CPU-intensive: no files to get)

$ pwd                                            (what directory am I currently working in?)
/usr/dave

$ cd ..;pwd                                      (go up one branch and tell me where I am)
/usr

$ ls                                             (what files or directories are here?)
adm         demo        ega         include     man         preserve    tmp
bill        dict        games       lib         mbsi        spool
bin         dave        garp        lost+found  news        src

$ cd;ls                                          (go back to home directory and list files)
a.out       bin         mbox        sieve.c     src         testl.c

$ ls -al                                         (show in long format with hidden files)
total 113
drwxr-xr-x 5 dave        224 Mar 30 18:53 .
drwxr-xr-x23 root        544 Mar  7 11:05 ..
-rw-r--r-- 1 dave          0 Feb 11 22:20 .news_time
drwx------ 2 dave        240 Nov 13 14:49 .personal
-rw-r--r-- 1 dave        183 Feb 27 03:37 .profile
-rw-r----- 1 dave      42170 Mar  5 23:36 .rogue.save
-rwxr-xr-x 1 dave       8696 Mar 30 18:53 a.out
drwx------ 2 dave         32 Oct  4 17:02 bin
-rw-r----- 1 root        576 Oct 12 21:33 mbox
-rw-r----- 1 dave        904 Oct 21 15:46 sieve.c
drwx------ 2 dave         32 Oct  4 17:02 src
-rw-r----- 1 dave         79 Oct 21 15:46 testl.c


$ cat .profile                                   (look at Shell program executed at login)
                                                 (here some Shell variables are set)
PATH=:${HOME}/bin$PATH:/usr/games                (set default command search path)
SHELL=/bin/sh                                    (tells which Shell I'm using)
ED=/bin/vi                                       (and which editor)
export PATH SHELL ED                             (lets these variables be used later)
umask 027                                        (sets default protection)
stty -tabs                                       (and my desired terminal settings)

$ stty                                           (look at current terminal settings)
speed 1200 baud
erase = ^H; kill = @; intr = ^?; quit = ^\
start = ^Q; stop = ^S; eof = ^D; brk <undef>
even odd -raw -nl echo -lcase -tabs -cbreak


$ mail root                                      (complain to the super-user that my
                                                 backspace key doesn't work correctly)
```

Listing 1 continued on page 194

Looking Good!



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Listing 1 continued:

```
is there a problem with stty accepting ^H as erase? my stty
is set that way but the system doesn't seem to see them.


$ ls -l /                              (look at files under the root directory)
total 823
drwxr-xr-x 2 root       32 Feb 10 14:49 bck
drwxr-xr-x 2 root     2880 Mar 23 22:35 bin
drwxr-xr-x 3 root     3552 Mar 11 20:57 dev
drwxr-xr-x 2 root      320 Feb 12 02:26 etc
drwxr-xr-x 3 root      576 Feb 18 20:18 lib
drwxr-xr-x 2 root       32 Jan  5 23:38 lost+found
-rw-rw-rw- 1 root     3862 Mar 16 08:08 rst011966
drwxrwxrwx 2 root      544 Mar 30 18:55 tmp
drwxr-xr-x 5 root       80 Feb 18 21:02 unify
-rwx------ 1 root    67487 Jan 19 08:26 unix
drwxr-xr-x23 root      544 Mar  7 11:05 usr

$ ls -ld /etc                          (look at protections on /etc directory)
drwxr-xr-x 2 root      320 Feb 12 02:26 /etc

$ cat /etc/passwd                      (look at system password file)
root:/uwAMrSGHnJIw:0:0::/:/bin/sh
daemon:x:1:1::/:
sync::1:1:sync command:/tmp:/bin/sync
bin:x:3:3::/bin:
uucp:not-now:4:4::/usr/spool/uucppublic:/usr/lib/uucp/uucico
dave:RMuFz3n/yNaPo:10:2:Dave Fiedler (InfoPro Systems):/usr/dave:/bin/sh
demo::100:100:guest account:/usr/demo:/bin/sh

$ fortune                              (fortune "cookie" selected at random)
As the trials of life continue to take their toll, remember that there
is always a future in Computer Maintenance.

                                       (typed control-d and ended input to Shell)
login:
```

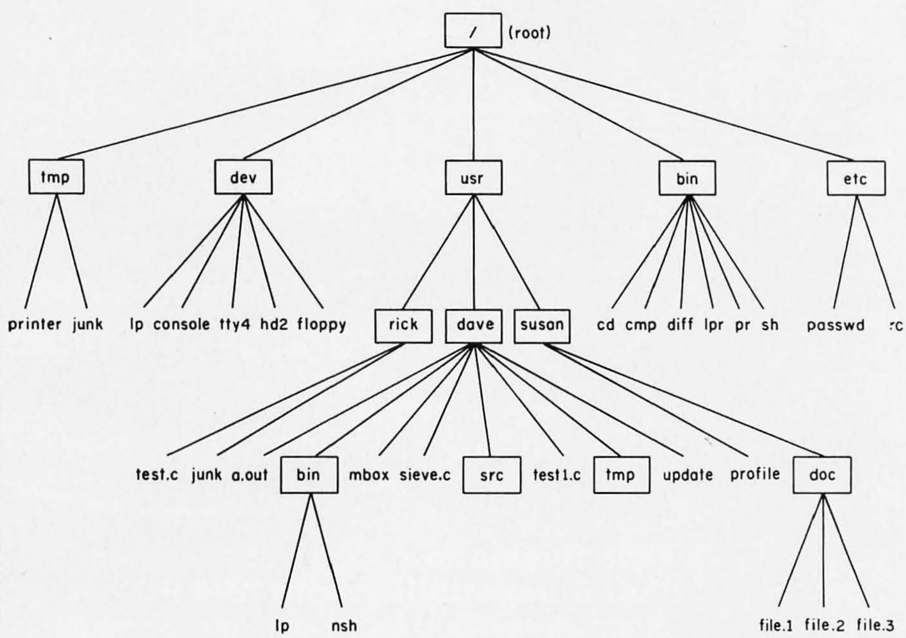

Figure 2: *Part of a simple Unix file system. The hierarchical file structure organizes files and allows the use of the same file name within different directories. The directory files are symbolized with a block outline.*

When the person administrating the Unix system initially sets it up, he or she can allocate more space to the /usr directory (and therefore the files under it) by setting up /usr as a logically separate file system. While this separate file system can physically reside on a distinct section of a disk (usually a Winchester disk or removable disk pack), it can also be on a totally different disk than the rest of the system; it can even take up an entire disk if needed. Not only can this allocation be changed later, it can

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Spellguard		$ 195	$129
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SYNAPSE. File Manager		$ 150	$ 99
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VisiDex or VisiSchedule, each		$ 250	$199
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MICROCOM. Microterminal		$ 100	$ 65
MICROSTUF. Crosstalk		$ 195	$129
NAGY SYSTEMS. Copy PC. Back and Utilities		$ 35	$ 25
NORELL DATA. System Back		$ 50	$ 39
NORTON. Norton Utilities. 14 powerful programs, 3 disks		$ 80	$ 65

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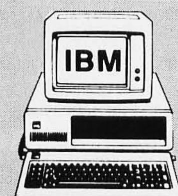

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★ Quadboard 256K, four function board	$ 595	$ 425
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Quad 512 + , 256K plus serial port	$ 550	$ 440
Quad 512 + , 512K plus serial port	$ 895	$ 675
Quadcolor I	$ 295	$ 235
Microfazer, w Copy, Par Par, 8K, #MP8 w Power Supply	$ 189	$ 139
Microfazer, w Copy, Par Par, 64K, #MP64 w Power Supply	$ 319	$ 235
Microfazer, w Copy, Par Par, 128K, #MP128 w Power Supply	$ 465	$ 345
Microfazer, Snap-on, 8K, Par Par, Epson, #ME8, w Power Supply	$ 179	$ 145
Microfazer, Snap-on, 64K, Par Par, Epson, #ME64, w Pwr. Supply	$ 319	$ 235
All Microfazers are expandable (w copy to 512K) (Snap-on to 64K)		
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	2 or more	$ 529	$ 239
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	10-12MB	$2395	$1495
	15-19MB	$2795	$1895
MAYNARD. Floppy Drive Control Board, for up to 4 drives.		$ 195	$ 165
same with Serial Port		$ 325	$ 235
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PRACTICAL PERIPHERALS. Microbuffer In-Line 64K Parallel Universal Buffer		$ 349	$ 259
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9x9 Dot Matrix, 100cps, 2.3K, Gemini 15"		$ 649	$ 469
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Grappler + by Orange Micro, specify printer		$ 165	$ 119
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TPI Tractor Feed		$ 149	$ 129

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MICROPRO, WordStar* plus free WordStar Training Manual		$ 495	$ 269
MailMerge* (Call on 2 Pak, 3 Pak and others)		$ 250	$ 129
SpellStar*		$ 250	$ 129
WordStar Professional, 4 Pak, 3 above + StarIndex		$ 895	$ 429
InfoStar	NEW!	$ 495	$ 269
ReportStar	NEW!	$ 350	$ 199
MICROSOFT Multiplan		$ 275	$ 199
Fortran 80		$ 500	$ 325
BASIC Compiler		$ 395	$ 295
COBOL-80		$ 750	$ 545
BASIC-80 Interpreter		$ 350	$ 275
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Edit-80		$ 120	$ 80
Macro-80		$ 200	$ 145

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12" Amber, #300A	$ 210	$ 159
★ 13" Color I, Composite	$ 379	$ 299
★ 13" Color II, RGB, Hi Res (Ap. II, III & IBM-PC)	$ 529	$ 459
★ 13" Color III, RGB, Commercial. (Ap. II, III)	$ 479	$ 399
DVM, Color II or III to Apple II Interface	$ 199	$ 175
NEC, 12" Green, Model JB1201M	$ 249	$ 159
12" Color, Composite, Model JC1212M	$ 450	$ 349
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QUADRAM, Quadchrome 12" RGB Color	$ 795	$ 565
SANYO, 9" Green, Model DM5109	$ 200	$ 139
12" Green, Model DM8112CX	$ 260	$ 199
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TAXAN, RGB Vision I 380 Lines	$ 399	$ 339
ZENITH, 12" Green, Model ZVM121	$ 150	$ 99

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AXLON, Datalink 1000 Hand Held Communications Terminal	$ 399	$ 299
HAYES, Micromodem II (for the Apple II)	$ 379	$ 275
Apple Terminal Program for Micromodem II	$ 100	$ 65
IBM-PC Smartcom II	$ 119	$ 89
Stock Chronograph (RS-232)	$ 249	$ 189
Smartmodem 300 (RS-232)	$ 289	$ 225
Smartmodem 1200 (RS-232)	$ 699	$ 535
Micromodem 100 (S-100 bus)	$ 399	$ 275
IBM-PC to Modem Cable	$ 39	$ 29
MICROCOM, Micro Courier for Apple II	$ 250	$ 125
Micro Telegram for Apple II	$ 250	$ 125
NOVATION, Applecat II Modem, 300 BAUD	$ 389	$ 269
212 Apple Cat, 1200 BAUD	$ 725	$ 599
SIGNALMAN, Modem MKI (RS-232)	$ 99	$ 79
SSM, Transcend 1 for Apple II Data Comm.	$ 89	$ 69
ModemCard for the Apple II	$ 299	$ 259

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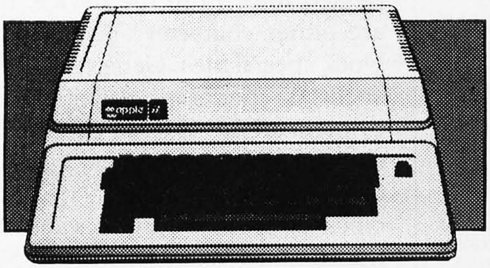

APPLE IIe 64K, 40 COLUMN	**$1,175**
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APPLE IIe, STARTER SYSTEM BY APPLE (System A)	
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Sanyo 9" Green Monitor	
RF Modulator (for color TV)	
Game Paddles	
Game with color graphics and sound	**$1,875**

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To substitute or delete drive on System B, subtract $245 and add drive price (System D)

To add on Micro-Sci A2 Drive to above, add $245. (System DD)

To substitute or delete monitor on System B, subtract $130 and add other monitor price (System M).

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		LIST PRICE	OUR PRICE
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	Controller Card for A2 Drive	$ 100	$ 79
	★A40, 5-1/4", 160K Disk Drive	$ 449	$ 299
	★A70, 5-1/4", 286K Disk Drive	$ 599	$ 299
	Controller for A40 or A70	$ 100	$ 79
	Filei, Disk Utility Software	$ 20	$ 15
VISTA	Solo, 5" 143K Disk Drive Std. Height	$ 300	$ 249
	Duet, 5", Double Sided, 320K Half Height	$ 420	$ 329
	Quartet, 5", 2 Duets Side by Side or Standard Cabinet	$ 715	$ 575
	Controller Card	$ 89	$ 75
	★V1000 Dual 8", Std. Format w/Controller, Complete	$2195	$1295
TEAC	✱143K Disk Drive, 1/2 High	$ 379	$ 279
	Controller Card.	$ 89	$ 69
	✱Electronics by ComX		
★ **CENTRAL POINT**, Filer, Utility and DOS 3.3		$ 20	$ 15

HARDWARE
for Apple II

RAM EXPANSION

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★ **ComX**, RAM Card, 2 Yr. Wty. (II+) 16K	$ 179	$ 39
★ **ALS**, ADDRam (II+) 16K	$ 100	$ 69
★ **Microsoft**, RAMCard (II+) 16K	$ 100	$ 79
★ **Saturn Systems**, RAM Card (II+) 32K	$ 249	$169
RAM Card (II+) 64K	$ 425	$319
RAM Card II(+) 128K	$ 599	$459
★ **Axlon RAM Disk System** (+ or e) 320K	$1395	$795

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★ **ALS**, Smarterm II (+ or e)	$ 179	$139
ComX, 80 col./64K Adder (IIe)	$ 295	$145
Videx, Videoterm 80 col. (+ or e)	$ 345	$229
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Soft Video Switch (II+)	$ 35	$ 25
Enhancer II (II+)	$ 149	$ 99
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Full Videx Line. Call. Up to 35% off.		
Vista, Vision 80	$ 289	$199

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ALS, The CP/M Card V3.0 (+ or e)	$ 399	$299
Z-Card (+ or e)	$ 169	$129
Color II (+ or e)	$ 179	$139
ASTAR, RF Modulator	$ 35	$ 25
CCS, Serial Interface 7710A	$ 150	$129
Dan Paymar, Lower Case Chip (II+)	$ 50	$ 39
Don't Ask, DAO 003 S.A. Mouth	$ 125	$ 85
★ **Eastside**, Wild Card, copier	$ 130	$ 99
Kensington, System Saver	$ 90	$ 69
Key Tronic, KB200 keyboard, 84 keys (II+)	$ 298	$198
Kraft, Joystick (Ap II/II+)	$ 65	$ 49
Paddle (Ap II/II+)	$ 50	$ 39
M&R, Sup R fan	$ 50	$ 39
★ **Microsoft**, Z80 Softcard (+ or e)	$ 345	$235
Z80 Softcard Plus (+ or e)	$ 645	$459
Softcard Premium Pack (II+)	$ 695	$495
Softcard Premium Pack (IIe)	$ 495	$395
Micro Tek, Dumpling 64, Buffer	$ 349	$269
★ **Orange Micro**, Grappler Plus	$ 165	$119
Practical Peripherals.		
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MBS IIe 32K Ser. (Epson Internal) (+/e)	$ 219	$169
Microbuffer II+, 16K, (+ or e) Par/Ser (specify)	$ 259	$199
Microbuffer II+, 64K, (+ or e) Par/Ser (specify)	$ 349	$259
PCPI, Appli-Card, 14 features 4 Mhz	$ 295	$235
6 Mhz	$ 375	$275
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SSM, A10 II, Serial/Para Interface	$ 225	$169
TG Products, Game Paddles (II+)	$ 40	$ 29
Joystick (II+)	$ 60	$ 45
Select-A-Port (II+)	$ 60	$ 45
Trak Ball (II+)	$ 65	$ 44
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WICO, Trackball (Ap II/II+)	$ 90	$ 61
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on disk for Apple II/II+/IIE

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FCM	$ 100	$ 68
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Hayden, Pie Writer (Specify brd.)	$ 150	$ 99
Howard Soft, Real Estate Analyzer II	$ 195	$129
Tax Preparer	$ 225	$149
Info. Unlim., Easywriter (PRO)	$ 175	$119
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Verdict, (Legal Billing)	$ 995	$469
★ **Micro Lab**, Tax Manager	$ 180	$119
Micro Pro, (all require Z80-CP/M Card)		
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MailMerge™ SPECIAL	$ 250	$129
SpellStar™ SPECIAL	$ 250	$129
WordStar Professional, 4 Pak, 3 above + Star Index SPECIAL	$ 895	$429
WordStar w/Applicard & CP/M (special)	$ 495	$345
Microsoft, Multi-Plan (CP/M or Apple DOS)	$ 275	$199
Financial, Multitool (CP/M or DOS)	$ 100	$ 75
Budget, Multitool (CP/M or DOS)	$ 150	$115
Sierra/On-Line, ScreenWriter II	$ 130	$ 89
The Dictionary NEW!	$ 100	$ 69
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Series 9 Text & Spell & Mail, all 3	$ 595	$395
Perfect, Perfect Writer	$ 495	$219
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Perfect Writer/Speller 2 Pak	$ 695	$299
Perfect Filer	$ 595	$259
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Sof./Sys., Executive Secretary	$ 250	$169
Executive Speller	$ 75	$ 55
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(specify + or e) PFS: Report	$ 125	$ 85
PFS: Graph	$ 125	$ 85
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DB Master 3 Pak, Special	$ 687	$387
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Visicalc 80 col. preboot disk	$ 50	$ 39
Visicalc 80 col. to 176K disk	$ 90	$ 69
Videoterm Utilities Disk	$ 37	$ 28
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Apple Mechanic	$ 30	$ 22
Central Point, Filer, DOS Utility	$ 20	$ 15
★ Copy II Plus (bit copier)	$ 40	$ 35
Computer Appli., Nibbles Away II	$ 70	$ 59
Epson, Graphics Dump	$ 15	$ 9
Insoft, GraFORTH by Paul Lutus	$ 75	$ 59
Microsoft, A.L.D.S.	$ 125	$ 75
BASIC Compiler	$ 395	$299
Cobol 80	$ 750	$559
Fortran 80	$ 195	$149
TASC Compiler	$ 175	$159
★ **Omega**, Locksmith (bit copier)	$ 100	$ 75
Penguin, Comp. Grphcs. Sys. NEW!	$ 70	$ 53
Graphics Magician NEW!	$ 60	$ 41
Phoenix, Zoom Grafix	$ 40	$ 34
Quality, Bag of Tricks NEW!	$ 40	$ 29
Saturn Systems, VC-Expand	$ 100	$ 49
VC-Expand 80	$ 125	$ 69
Sensible, Back it Up, (bit copier)	$ 60	$ 49

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rhd1	—"raw" access to hard disk 1
tty0	—"teletype" 0—a user terminal or modem
tty1	—"teletype" 1—a user terminal or modem
tty2	—"teletype" 2—a user terminal or modem
tty3	—"teletype" 3—a user terminal or modem

Table 1: *A typical listing of the files in the* /dev *(device) directory with descriptions of each device.*

Listing 2: *A typical directory listing for a user on a Unix system employing the list directory* (ls) *command with the* -l *(long form) option.*

```
$ ls -l
-rwxr-xr-x 1 dave        8696 Mar 26 18:53 a.out
drwxr-xr-x 2 dave          80 Oct  4 17:02 bin
-rw-rw---- 1 dave         576 Oct 12 21:33 mbox
-rw-r--r-- 1 dave         904 Oct 21 15:46 sieve.c
drwx------ 2 dave         149 Oct  4 17:02 src
-rw-r--r-- 1 dave          79 Oct 21 15:46 test1.c
drwxrwxrwx 2 dave          48 Mar 26 18:55 tmp
-rwxr--r-- 1 dave        3508 Nov 23 13:11 update
$
```

also be done *at any level* of the file system. This means that one of your lowest-level subdirectories can be reassigned to reside on another device, expanding theoretical storage space almost ad infinitum (each file can contain almost 2^{30} bytes, and thousands of files are possible on a system).

I/O Independence

The I/O (input/output) system on Unix is easy to understand. Every physical device supported by the system appears, like a file, as an entry in the /dev (device) directory. Users and programs running on Unix handle the devices as if they actually were files. A typical listing of the files in the /dev directory might look similar to the left-hand column of table 1 (descriptions of each device are on the right).

Notice that every physical resource on the system is accessed as if it were a regular file, even memory itself. To send characters to the line printer, you just issue a system write command to the file /dev/lp. If you want to debug a new disk device driver you can read, say, the file /dev/rhd1, which will show you exactly what's on a particular hard disk in "raw" form (i.e., not under control of the file system). Changing one byte in memory would involve writing the byte to /dev/mem.

While users can treat devices like files, to the Unix system programmer they are still devices, which must have device-driver programs written for them so they can communicate with the system. The device drivers are loaded into /unix, the executable code that is the actual operating system, before you receive your Unix-equipped computer. Because the operating system must access devices through these driver programs, the devices are also known as *special files.* Depending on how information is passed to or from the device, these are either character special files or block special files. Generally, devices such as modems, terminals, and printers are considered character-by-character devices, while disks and tape drives are usually treated as block-by-block devices because they transfer data in larger blocks of 512 or 1024 bytes for efficiency.

File Security

Naturally, some control must be exercised over devices and files. Several people trying to write to the printer at once would result in confused program listings, and letting just anyone write to random spots in memory would soon crash the system. In addition, you wouldn't want other people to be able to read or erase your personal files. Unix provides this control in a simple but effective way. Each file has an associated group of protection bits (also known as mode bits), which the owner of the file can control individually.

The values of these bits may be seen for any file on Unix by executing the ls list directory command with the -l (long form) option. Listing 2 shows a typical directory listing. If a bit is set (turned on, or enabled) its value is visible; otherwise, you simply see a hyphen.

The 10 bits shown for each file include a directory bit (d—not actually a protection bit), 3 "user" protection bits (rwx, for read, write, and execute), 3 "group" protection bits (rwx), and 3 "other" protection bits (rwx). An enabled directory bit means that the file in question is a directory. The three sets of protection bits tell how the *user* (owner of the file), his or her working *group* (a collection of other people wishing to share file access for a project), or all *other* system users can access the file. When the

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read or write bit is enabled for one of these groups of bits, a user belonging to that group is permitted read or write access. When the read bit, but not the write bit, is set, you cannot add to, change, or destroy the file. This kind of protection is usually used for data files accessible to all, such as the system header files any C programmer might need. If the write bit, but not the read bit, is set, you have a "write-only" file. This is handy for creating system accounting log files where information about what people do on the system is kept. It may not be desirable to allow such information to be available to all users. When the execute bit is enabled, it means that the file may be executed as a program because it's either object code or a Shell program (I'll explain more about this later).

The significance of these bits is slightly altered when applied to directories. If the write bit is enabled for a directory, it means that files may be created or deleted in the directory. When the execute bit is turned on, you may then search through the files in the directory and read, write, and execute these files if permitted by the protection bits on the files themselves. If only the read bit is enabled, you may simply read the directory as a file, and you have limited access to the names of the files and their pointer information. The system administrator or *super-user* can bypass all file protections.

Because only an owner of a file or the super-user may change the values of these bits with the chmod command, the security on Unix is as good as users wish it to be. The umask command allows you to set the default protection for all files you create, from rw------- for the suspicious to rw-rw-rw- for the trusting.

Redirection and Pipes

Most people who regularly run programs on computer systems don't concern themselves with where the program input comes from—usually it comes from their terminal, another predefined device such as a tape drive, or a dedicated data file.

File security in Unix is almost entirely up to each user.

Similarly, the output of a program is generally expected to end up on their terminal, in a new data file, or on the system printer. On Unix, you can easily arrange for your programs to get their input from any file or device you have access to (and it's equally easy to redirect output). Let's look at how Unix handles this procedure and you'll wonder why other operating systems weren't set up to do it this way.

Remember that devices are treated as files, and so to send a directory listing to the printer, you just type the following:

```
$ ls > /dev/lp
$
```

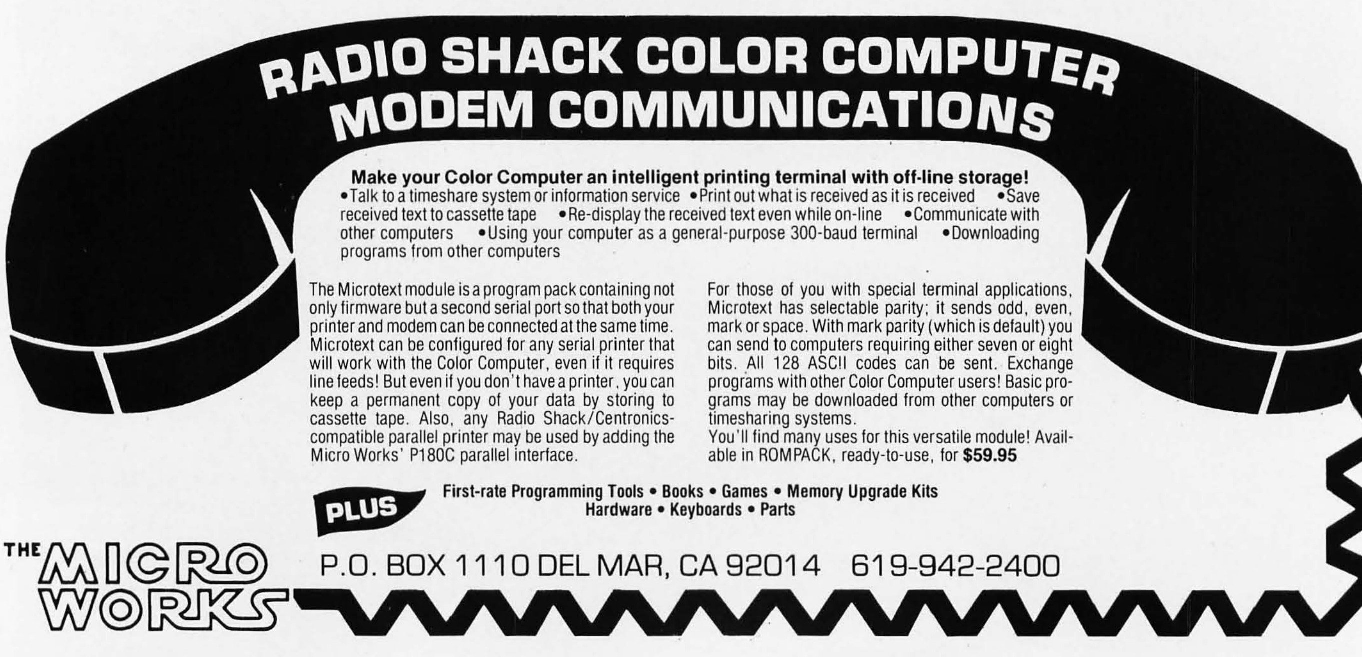
The "greater than" (>) character sends the output of the ls command (which would normally print a list of files on your terminal) to the system printer. The dollar sign ($) is the Unix prompt character (some versions of Unix use the percent sign (%) for the same purpose).

Input to a program can be controlled in a similar way. For example, if a file on the disk called textfile contains a list of words, we can find the spelling errors in the file and have them appear on the terminal with the command

```
$ spell < textfile
```

The "less than" (<) character redirects the input of the spell command to come from the disk file (notice the mnemonic nature of the characters used: each one points in the direction of data transfer).

Where would input normally come from? The typical Unix program has one source of input and only one type of output. Such a program is known as a *filter* if it simply accepts



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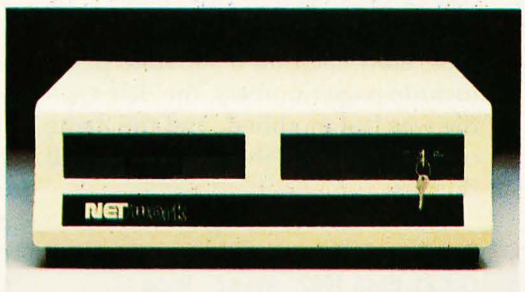

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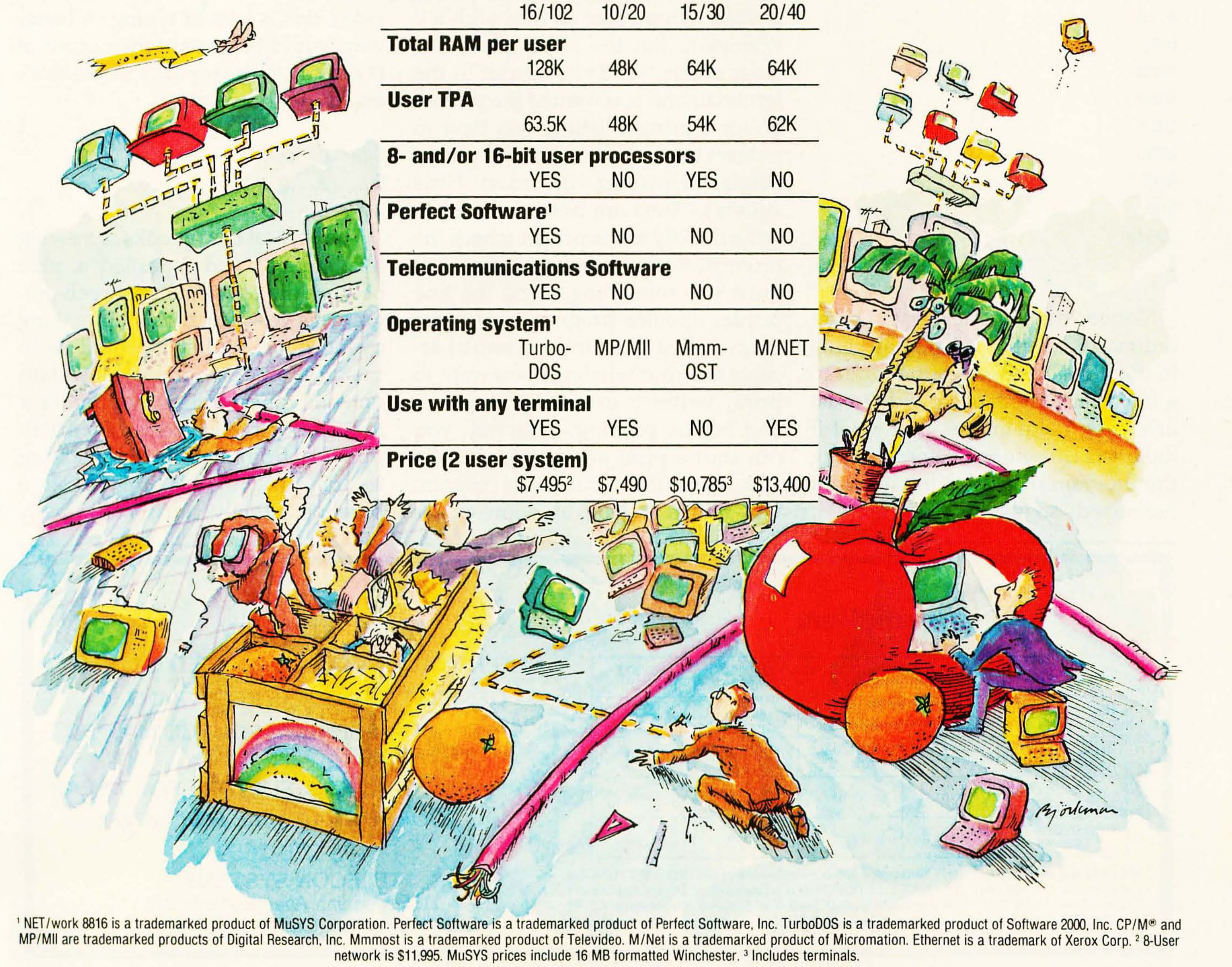

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its input, performs some function on it, and emits the processed data as output. The system causes the default, or *standard*, input and output "files" to be the user's terminal unless otherwise redirected. So, for example, you can redirect the output of ls to a file in the following manner:

```
$ ls > temp
$
```

Now if you look at the file temp, you'll see the names of the files in your directory. The all-purpose program cat (short for concatenate) can be used to collect several files and put them all together. In the following example we'll simply use cat to show the contents of temp without formatting, using the directory from listing 2:

```
$ cat temp
a.out
bin
mbox
sieve.c
src
temp
test1.c
tmp
update
$
```

Notice the file temp you just redirected input to is listed as being in the directory. Redirecting input to a file creates the file if it didn't exist or erases it and creates it anew if it did exist. This is done before running the program that is having its input redirected; so when ls executed, it picked up the temp file from the directory. Using the operator twice (>>) signals that you wish to add to the end of the file if it exists; this is useful for collecting data. If you now want to print out all the C source files, start each on a separate page, include page numbers, the date each file was last modified, and the name of each file, then the pr program will do this:

```
$ pr *.c
Oct 21 15:46 1982   sieve.c   Page 1
/* Eratosthenes Sieve
Prime Number Program in C */
#define true 1
#define false 0
#define size
(interrupted)
$
```

Note that the almost universal wild-card character, the asterisk (*), is used to represent all files with a .c extension. But the pr program, like most others, sends its output to the terminal, and you wanted the printer. So for a printed listing, you have to redirect the output of pr to the printer (/dev/lp). However, on most Unix systems, users are not permitted to write directly to the printer (check the protection bits on your system), but must use something called the line printer spooler program. This program (called lpr on most systems) accepts as input whatever you want to print, writes it to a temporary file, and begins printing. This way, you can start a print job that might take an hour to finish, but the lpr program will return to you as soon as it's finished copying your files, so you can continue working. Now if you say

```
$ lpr *.c
$
```

you get your prompt back almost immediately, and meanwhile the files are being printed. But when you look at them, you find both files are printed one after the other, with no page numbers or even expansion of tab characters. You really wanted pr to format them, so you can do this:

```
$ pr *.c > temp1
$ lpr temp1
$
```

Now we formatted the output properly, sent it to a file, then printed the file. We are also starting to leave files around to mess up our directory. Besides, this is a lot of typing. A better way would be to pass the output of pr directly to the input of lpr. So that's exactly what we do:

```
$ pr *.c | lpr
$
```

The vertical bar (|) looks somewhat like a pipe, and is called a pipe because the connection between programs is very much like a plumbing connection. At first it would seem that the pipe is simply an elegant notation for sending the output of pr to a temporary file, redirecting the input of lpr from that file, then erasing the file. In Unix, all programs in a pipeline actually run *simultaneously*

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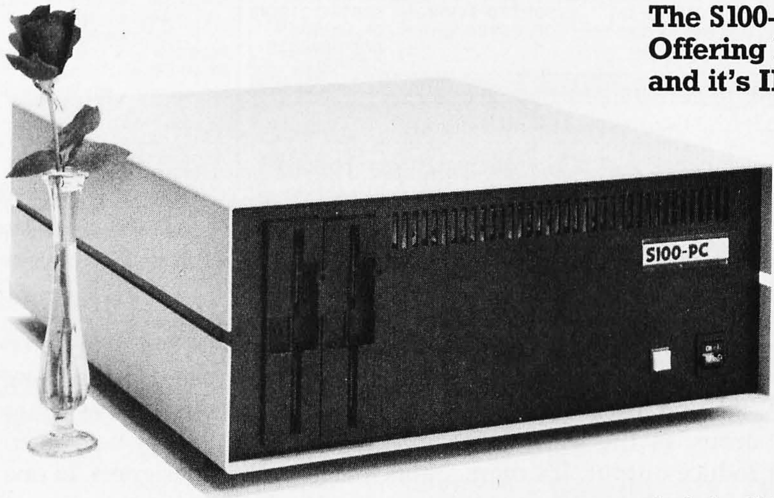

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Multitasking

Unix, of course, is a timesharing system, which means that more than one person can share the resources of a single computer and its set of storage devices and peripherals. Aside from being a multiuser system, Unix is also multitasking, splitting the available processor time among the various programs run by the users on the system. Even in the smallest Unix environments, where only one person at a time can use the system, this multitasking facility can speed up your work quite a bit.

Suppose you are writing a C program and its documentation. You write the latest changes of your program to disk, request a Unix command line while remaining in the editor, then type the following:

```
$ (cc test2.c 2>errors ; echo check errors) &
5179
$
```

This illustrates several features at once. First, note the parentheses around most of the command line. This treats the enclosed commands as a unit. There are actually two commands on this line, separated by a semicolon, which signifies that they are to be run sequentially. The cc command calls for the C program test2.c to be compiled, while the number 2 before the output redirection symbol means that only the standard error output (always referred to by the number 2) is to be redirected to a file called errors. When this compile is done, the echo program is run, which simply sends its arguments to the standard output. Because no redirection is called for, the message will appear at your terminal when the compilation is done. But you don't have to sit there waiting for it because the ampersand (&) at the end of the command line means that both commands (remember the parentheses) will run in the "background" as one. The prompt comes back instantly, preceded by an identification number for the background process. Very simply, this means that your job is running, and you don't have to wait for it to finish before continuing your work.

Meanwhile, you've gone back to editing your documentation file. When the message check errors appears on your screen, you write your text out to a file (possibly also beginning to print it in background), read in the errors file, note the line numbers of any errors, and fix them by editing test2.c. You can, of course, switch between any two or more tasks. It's much easier to sit down and do this than to read about it; it's a very natural way to work, and fast even on small Unix machines.

Every separate program running on Unix is called a *process*. Each process has a unique process identification number (PID). It's this PID that is displayed when you start up a background process, so that if you find the process has gotten stuck or is running too long, you can stop it by typing kill *PID*, where PID is that process identification number. You can also check its progress with the ps (process status) command, which will tell you how much processor time each of your programs has used.

Text continued on page 210

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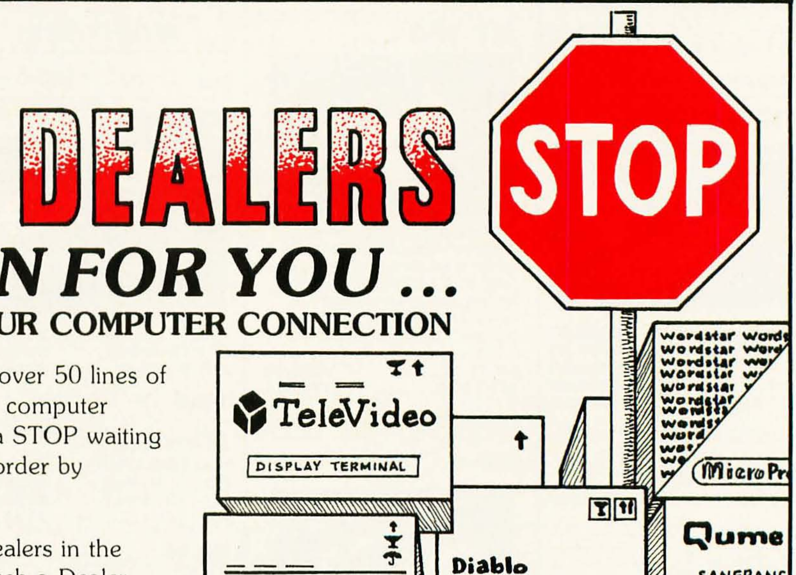

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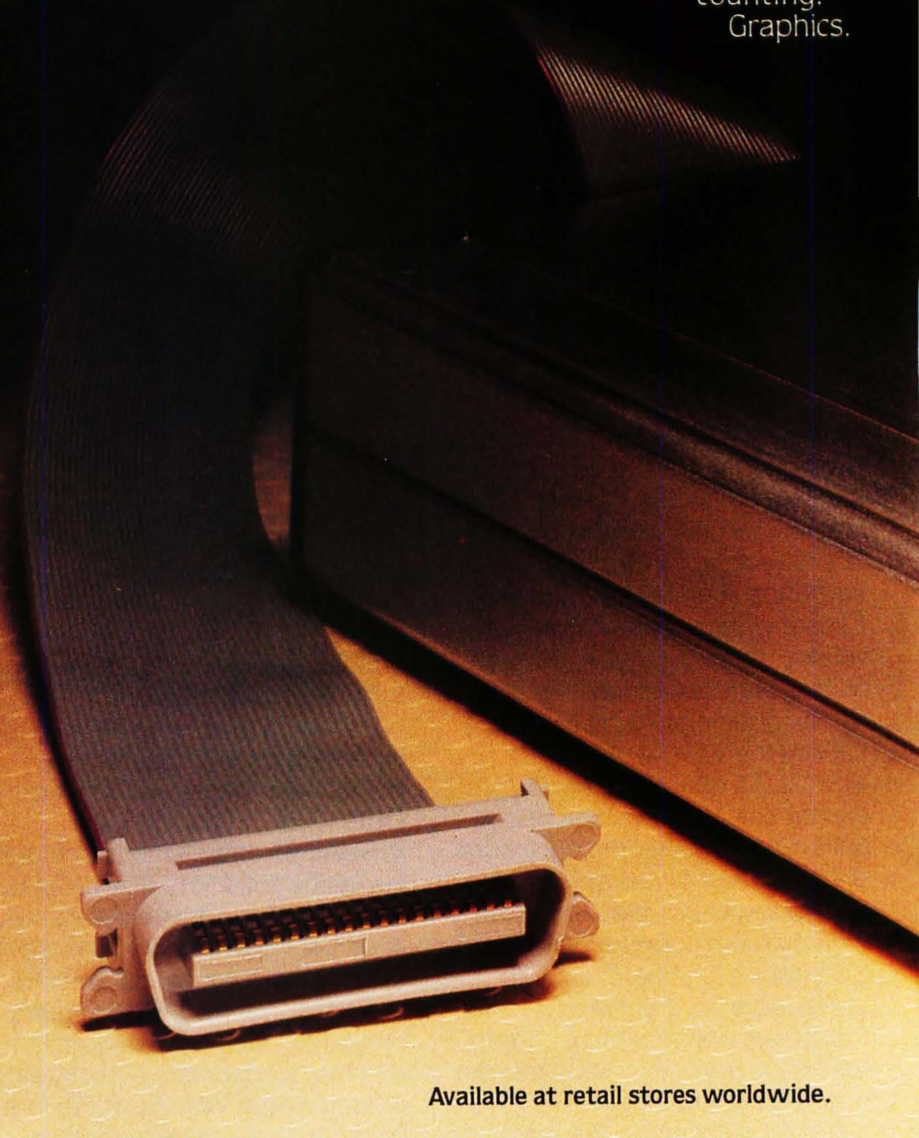

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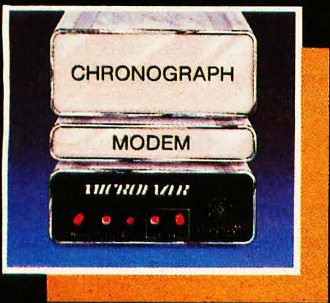

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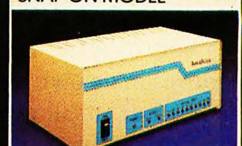
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The Shell

Many of the features I've described, while physically implemented in the low-level guts of the system, are controlled by the program you interact with most on Unix—the Shell. The Shell program is run each time you actually log onto the system. Because it is just another program, it can be changed or replaced if you don't like its function.

The Shell is responsible for the user interface to the system. It causes your prompt to be displayed, accepts your commands and causes them to be executed, expands wild-card symbols to provide a complete list of file names to pass to the programs, interprets and processes all the metacharacters (such as &, >, <, |, (,), and ;), and allows you to write fairly complex procedures in its own structured language. Further, it allows you to save a series of personal commands and use them as any other command on Unix.

When sending C files to the printer with pipes, suppose you don't want to type pr *.c | lpr all the time, especially after you find out that the default width of a pr listing is only 72 columns and you have a 132-column printer. Instead, try writing a simple command line with the cat command, taking input from the terminal and directing it into a file:

```
$ cat > lp
(pr -w132 $* | lpr) &
^D
$
```

The ^D (control-d) is taken to be the end of input by many programs on Unix, among them cat, mail, and the Shell. Now the file lp has that single line you typed: it's set up permanently to provide pr with 132-column output if necessary, and the entire pipeline is put in the background for even faster response. But what's that $*, and how do you execute this as a command?

The explanation is rather involved. Any list of valid commands that can be entered to the Shell may be stored in a file and presented to the Shell for execution. One simple way is by redirection:

```
$ sh < command_list
. . . execution of commands. . .
$
```

Because you're already running under the Shell, the effect of this is to start up a *new* Shell as a process, which then executes your commands, ends, and returns to you. In fact, this is the way all commands are executed from the Shell; the currently running Shell makes a fork system call, effectively reproducing itself, then waiting for the "child" Shell to finish. You can also use the chmod command described before to make the file of commands executable; after that, only the name of the file needs to be typed. When the Shell reads a command file that has been thus marked executable, it will execute each command in the file. So you would type:

```
$ chmod +x command_list
$ command_list
. . . execution of commands . . .
$
```


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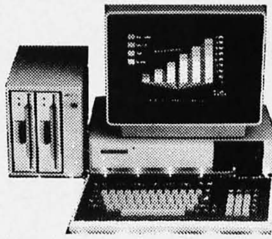

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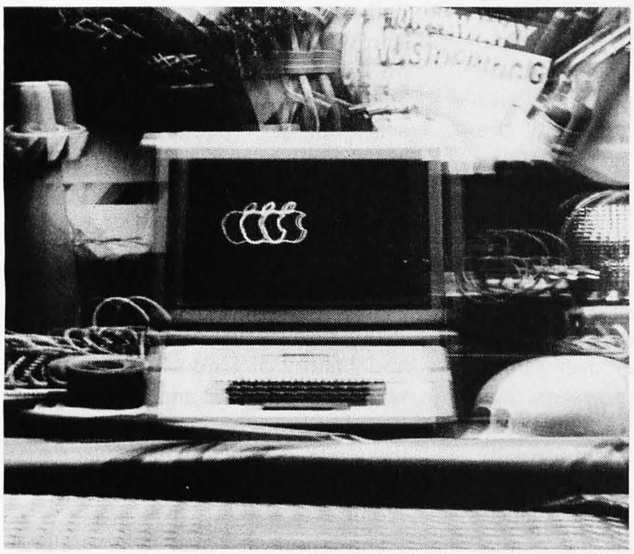

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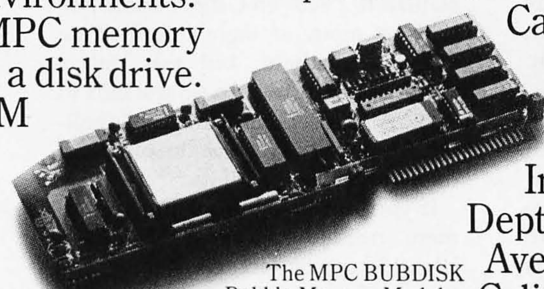

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A Survey of Unix and C Resources

by Walter Zintz

Unix and C users have many sources they can turn to for general help and moral support. Much of this help is free or available at minimal cost—in most cases, you'll find that the cult-like history of Unix has created an atmosphere of camaraderie rather than exclusivity.

At least three Unix user groups are active in the United States. The oldest, Usenix (POB 7, El Cerrito, CA 94530-0007, (415) 528-8649) is oriented toward university users; it offers a newsletter, conferences, and software distributions for source-license holders. Another organization, /usr/group (POB 8570, Stanford, CA 94035-0221) was founded by system vendors, although membership is open to users. The group publishes a newsletter and an annual Unix product directory, has committees actively working on Unix standardization and licensing, holds conferences, and offers sponsorship to local user groups. Uni-Ops (POB 5182, Walnut Creek, CA 94596-1182, (415) 945-0448) began with a nucleus of newer Unix end users who wanted to share information. Uni-Ops holds conferences, tutorials and local meetings, coproduces a newsletter and an online software index/exchange, sponsors a Berkeley Unix SIG (special interest group), and maintains a mailing list of Unix and C users. The C Users Group (POB 287, Yates Center, KS 66783, (316) 625-3554) was originally for users of a C language subset that runs under CP/M, but it now supports the general C community. The group has a newsletter and distributes software. Unix user associations are also active in Canada, Europe, Australia, and Japan.

Usenix holds the largest conferences, which are a common meeting ground for everyone involved in Unix, although the papers presented are often a bit esoteric; /usr/group conferences offer the best exposure to available products. Uni-Ops slants its conferences toward newcomers to Unix who want to know how to get started.

Other sources for newsletters include Southwater Corporation (30 Mowry St., Mount Carmel, CT 06518, (203) 288-0283), which publishes *World Unix & C*, a nontechnical newsletter in a newspaper format. Infopro Systems (POB 33, East Hanover, NJ 07936, (201) 625-2925) publishes *Unique*, a mixture of technical and product information. Urban Software Corporation (330 West 42nd St., New York, NY 10036, (212) 736-4030) publishes a somewhat eclectic newsletter called the *Urban Software Newsletter.*

Local user meetings are starting to take hold. Established, regular meetings are held in the Washington, DC, and Silicon Valley areas. For meeting schedules and agendas in either of those areas, contact Gary Donnelly (RLG Corp., Suite 508, 1760 Reston Ave., Reston, VA 22090) and Uni-Ops, respectively. Regular meetings are firming up in the Boston area, and several metropolitan areas in the Sunbelt are trying to get meetings started.

On Line

Electronic meetings using Unix's uucp utility are popular, too. By far the largest network is Usenet, in which systems poll each other over phone lines. Usenet allows intersystem mail at minimal cost, and Netnews as a bonus. To have your system formally admitted to Usenet, contact Stephen Daniel (Dept. of Computer Science, Room 201, North Building, Duke University, Durham, NC 27706, (919) 684-3048). Many new Usenet sites simply find a nearby installation that is already on Usenet and arrange to poll or be polled. A system that joins the net this way is not known to the Usenet software; it appears to Usenet as an individual user on the parent installation. I've seen Usenet addresses with as many as eight intermediate systems in them, but this delays messages and runs up phone bills to boot. Also, users on "hung-on" (polling or polled) systems do not have direct access to Netnews.

If you find that the polling equipment needed to access Usenet is beyond your budget, consider The C Line, a fledgling free service out of New Jersey. It's a message drop, bulletin board, and free software exchange for C language users. A new user need merely dial up the central computer, log on to the system, and begin browsing around. The C Line runs on a CP/M system, but it has two packages of Unix-like utilities to help Unix users feel at home. To access the C line, call (201) 625-1797 (with your modem set anywhere from 110 to 710 bits per second), hit a few carriage returns, then follow the system's prompts. The C Line is available at all hours except from 9:00 A.M. to 8:00 P.M. on weekdays; that's when the system's owners are using it for their own work.

Books

The serious Unix user also needs detailed information in printed form. Bell Laboratories is a good source to start with. It offers a flock of manuals on various aspects of System V and smaller but still substantial manual sets for earlier versions of Unix. These are thorough and rigorous (but not easy to read), and they're now available to anyone, with or without a Unix license. Bell Labs also has reprinted the *Bell System Technical Journal* special issue on Unix (July-August 1978), a wellspring on the philosophy and history of Unix. In conjunction with Holt, Rinehart and Winston, Bell Labs has brought out two volumes of the *UNIX Programmer's Manual* (New York: Holt, Rinehart and Winston, 1983).

The runaway best-seller among books on Unix, and deservedly so, is *A User Guide to the UNIX System* by Rebecca Thomas and Jean Yates (Berkeley, CA: Osborne/McGraw-Hill, 1982). Its technical chapters cover the most used Unix commands in clear style suited even to computing beginners, the resources sections are still useful as an elementary guide to software and services available, and the appendix has the complete official description of version 7 Unix as released by Bell Labs. Now, though, several newly published books are making strong bids for space on your bookshelf. *Introducing the UNIX System* by Henry McGilton and Rachel Morgan (New York: McGraw-Hill, 1983) has an ocean of information on what to do at a terminal or console. *The UNIX System* by Steve Bourne (Reading, MA: Addison-Wesley, 1983) is good on theory as well as practice,

and strong on the Bourne shell. *Unix Primer Plus* by Mitchell Waite, Donald Martin, and Steve Prata (Indianapolis, IN: Howard W. Sams and Co., 1983) will emphasize Berkeley Unix and be strong on logically organized reference tables and illustrative graphics.

There are worthwhile new books on C programming, too. Beginners, though probably not raw beginners, should consult *Learning to Program in C* by Thomas Plum (Cardiff, NJ: Plum Hall; 1983), which is rather complete for an introductory book and is not Unix-dependent. Plum also wrote *C Programming Standards and Guidelines* (Cardiff, NJ: Plum Hall, 1982). *The C Primer* by Les Hancock and Morris Krieger (New York: McGraw-Hill, 1982) is a good introduction to the language. People with some C experience can have fun while advancing their skills with *The C Puzzle Book* by Alan R. Feuer (Englewood Cliffs, NJ: Prentice-Hall, 1983), which is exactly what its name suggests. We mustn't overlook the standard reference work *The C Programming Language* by Brian Kernighan and Dennis Ritchie (Englewood Cliffs, NJ: Prentice-Hall, 1978) and *C Notes* by C. T. Zahn (New York: Yourdon Press, 1979).

With Unix's blooming popularity of late, your computer store or technical book shop may have the manuals and books you want. If not, three mail-order book servies specialize in Unix and C. All three have lists of the books and manuals they offer and their prices. Cucumber Bookshop Inc., (5611 Kraft Dr., Rockville, MD 20852, (301) 881-2722) is the oldest. The Unix Bookstore (47 Potomac Street, San Francisco, CA 94117, (415) 621-6415) is run by a veteran Unix and C instructor. Southwater Corp. (30 Mowry St., Mount Carmel, CT 06518, (203) 288-0283) also carries general programming books.

Courses

A flood of tutorial sources has emerged in the last year or so. Some organizations offer courses at your site, others schedule classes in major cities around the country, still others hold all their training at their own offices. Many have hands-on training, with one to three students per terminal, others teach through lectures and audiovisual materials.

Of the many tutorial firms these days, I can list only the most active ones. California firms include the Center for Advanced Professional Education Inc. (11928 North Earlham, Orange, CA 92669, (714) 633-9280), International Technical Seminars (47 Potomac St., San Francisco, CA 94117, (415) 621-6415), and The Wollongong Group (1135A San Antonio Rd., Palo Alto, CA 94303, (415) 962-9224).

In the Midwest, contact Uniq Computer Corp, (28 South Water St., Batavia, IL 60510, (312) 879-1566), the Computer Technology Group, (Telemedia Inc., 310 South Michigan Ave., Chicago IL 60604, (312) 987-4000), Unir Corp. (Suite 106, 5987 East 71st St., Indianapolis, IN 46220, (317) 842-7014), and, in Canada, Human Computing Resources Corp. (Suite 401, 10 Saint Mary St., Toronto, Ontario M4Y 1P9, Canada, (416) 922-1937).

On the East Coast, you can try RLG Corp. (Suite 508, 1760 Reston Ave., Reston, VA 22090, (703) 471-6860), Plum Hall Inc. (1 Spruce Ave., Cardiff, NJ 08232, (609) 927-3770), Structured Methods Inc. (7 West 18th St., New York, NY 10011, (212) 741-7720), DJR Associates Inc. (303 South Broadway, Tarrytown, NY 10591, (914) 631-6766), Training Services Group (Bunker Ramo Information Systems, Trumbull Industrial Park, Trumbull, CT 06609, (203) 386-2600), and the Institute for Advanced Professional Studies (55 Wheeler St., Cambridge, MA 02138, (617) 497-2075).

In the computer age it's practical to teach Unix and C without face-to-face meetings, and two organizations have software to do just that. User Training Corp. (POB 970, Soquel, CA 95073), (408) 354-6433) uses audio cassettes and a black box the firm manufactures to let you listen through earphones to an instructor's explanations while you watch an example displayed on your terminal screen. Uni-Ops (mentioned earlier) offers computer-managed-instruction interactive tutorials that can be run on any Unix system.

Walter Zintz is affiliated with Uni-Ops (POB 5182, Walnut Creek, CA 94596).

The dollar sign in $* is the Shell's notation for a parameter whose value you may change. If a digit followed the dollar sign, then the argument corresponding to that number is substituted ($0 would represent the command file name itself). The $* simply means to expand all arguments following the command file name and substitute them for the $*.

In the case of our new command lp above, now you need only type lp *.c to have all your C source files printed and nicely paged in the background. Even better than this is the programming language built into the Shell. Here's a quick example:

```
rm /tmp/cprinter
for i in *.c
do
   cc $i 2>$i.err
   cb $i | pr >> /tmp/cprinter
   pr $i.err >> /tmp/cprinter
done
lpr /tmp/cprinter
rm /tmp/cprinter
```

First, any temporary file with the given name (in this case, /tmp/cprinter) is removed. Then the program loops through each occurrence of a C source file by replacing the $i with the proper name, compiles it (sending the error output to a similarly named file; e.g., test.c would have an error file; test.c.err), runs the C beautifier (cb) program (which indents structures and loops), sends the result through pr to be paged and dated, and appends this to the temporary file. Then the error file is paged and appended. When all C files have been through this procedure, the temporary file is printed and removed.

Why go through all this? If the C compiler sees a list of files, it assumes they are all to be compiled and loaded together, and this is not always the case. And if all the output was not directed to the temporary file, we might have had 45 or so separate printouts from all the source and error files. This type of short program doesn't even have to be saved in a file; it could be typed directly into the Shell and interpreted on the spot. And much more elaborate programs

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Development Tools and Languages

The most important aspect of software development is whether the tools needed for development are available. Unix not only has a full set of interpreters and compilers for various languages, but also includes programs that can be invaluable in creating your own language processors.

A typical Unix system will come with a C compiler (cc), assembler (as), syntax and portability checker (lint), a loader (ld) for the processor the system runs on, an interpreter for a BASIC-like language (bs), and the C beautifier (cb) mentioned before. A set of programs, together called SCCS (Source Code Control System), allows all changes made to source files to be stored, so that a previous level of revision can be reconstructed at any time—a lifesaver for people who tend to lose track of their latest changes. A sophisticated file comparator (diff) shows the exact differences between two text files and, optionally, can tell the text editing program how to convert one to the other. A full FORTRAN 77 compiler (f77) and a structured Ratfor-to-FORTRAN filter (ratfor) are included, as are numerous programs used to plot graphical output on a variety of devices. You also get a general-purpose macro processor (M4), a SNOBOL interpreter (sno), a program that will let you generate programs to perform lexical analysis (lex), a string-processing language (awk), and a compiler generator (yacc), not to mention the typesetting program (troff) and its word-processing companion (nroff).

You can expect all of the above with standard Unix. Also available are cross-compilers for almost every type of microprocessor available, COBOL compilers, FORTH interpreters, various versions of Pascal and Ada, translators from several languages to C, and LISP. Each month I receive dozens of press releases about new software products for Unix systems, such as full-screen editors, word-processing packages, applications programs, and even a few CP/M emulators. Almost everything you could ever need to develop and use software on Unix is on the market; you just have to find it.

Communications

Unix was invented at Bell Laboratories, so it's not surprising that the system makes it easy for you to use the telephone network for computer-to-computer communications. Interpersonal communication is natural and uncomplicated on Unix. The command most people first discover is the impromptu write facility, which lets you exchange messages with another person currently logged into the system. Each of you can write a message, then wait for the other's answer; in this way, a slow conversation can take place.

If the party you wish to reach is not logged on, the write command will tell you so. In this case you can send electronic mail with the mail command and the recipient will be notified of its existence when he or she next logs on. Mail is postmarked with the date and time sent and who sent it. You can type outgoing mail directly from the terminal or use an editor and text formatter to make it a bit fancier. Mail can even be forwarded to other people, and you can send the same item to several people at once. The mail facility proves to be quite useful in an organizational setting because people can log on at any time and send a message they know will be received eventually. Mail to yourself is equally useful as a reminder, and all incoming mail can be saved for future use.

Mail can also be sent to remote systems semi-automatically. If your Unix system is capable of dialing the phone by an automatic calling unit or intelligent modem, it may already have been set up to use the uucp facility to access other Unix systems. The name uucp is an acronym for "Unix-to-Unix copy"; essentially it uses an error-checking protocol to allow files to be transferred between machines. The important thing about uucp is that, once set up, it is easy to operate. You need only specify the publicly known name of the reci-

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pient's machine and his or her user name, as in infopro!dave or decvax!aps. Then instead of sending to Ann by typing mail ann, you can just type mail harpo!ann if harpo is the name of Ann's machine, and this will automatically send the remote mail via uucp. If your computer is part of the informal uucpnet, you can specify a series of machine names through which the messages will be passed until the final destination is reached, as in decvax!harpo!floyd!infopro!dave. The advantage of this is that each machine in the chain only has to make a local or short-distance call, saving ultimately in telephone charges. Other similar networks exist, and in some the message will be automatically passed by the shortest available route. Regular program, text, and data files can also be sent and received using uucp, which is set up to dial in the middle of the night when phone rates are cheapest.

Transfer of data can also be initiated manually with the cu (call Unix) command. This lets you simply specify a phone number to be dialed, after which you can log onto the other machine, run programs, and send files back and forth. The combination of all these facilities allows Unix users all over the country to interact almost as if they were on one large machine. In addition, a few electronic news services enable people to conduct ongoing discussions, announce products, and spread rumors.

Unix Compared to Other Operating Systems

It's hard for some diehard buffs to remember that Unix isn't the only operating system around and that it still lacks a few important features.

Most inconvenient for business users is the lack of either file or record locking at the user program level. These facilities would allow several users to access the same database at once without fear that information would be inaccurate, as it can be when several different people write the same record simultaneously. While several commercially available database systems (such as MDBS III, Informix, and Mistress) handle this problem internally, Unix software designers are hampered without a standard set of system calls to depend on.

Real-time facilities that could guarantee a maximum known response time for selected programs would benefit not only laboratory researchers (for whom such facilities are absolutely essential) but also would allow acceptance of Unix in other markets where speed is necessary. A simple order-entry program can be brought to its knees by an nroff program run at the wrong moment when the system as a whole is not carefully tuned and monitored.

Each time a person logs onto Unix a new process is created. When attempting to put large numbers of users on a single computer system simultaneously, Unix system administrators find that the large number of processes thus created is itself a drain on the system. Unix spends a good deal of time in switching context between processes; so the net result of too many processes is a system that spends most of its time doing no productive work. This prevents Unix from replacing other operating systems in traditional data centers where one mainframe computer might serve hundreds of terminals. While it is likely that networks of small Unix-based workstations will tend to make such traditional configurations obsolete, certain applications may be restricted from using Unix for this reason.

Virtual memory is not yet supported, even on machine configurations where this is possible. While this feature and record/file locking are expected to be added in future Bell releases of Unix, it has so far remained the province of the University of California at Berkeley to support virtual memory with its release of Unix, known as 4.2 BSD. However, this version is not widely available on the commercial market.

It was once commonly accepted that a Unix guru had to be on call at all times to reconstruct the file system after the almost inevitable system failure. This is no longer true; utilities exist on Unix to fix the file system automatically after a crash, and crashes themselves are less frequent on newer releases due to improved ordering of disk writes and other factors. Nevertheless, while on many competing commercial systems all running programs will resume without error after a crash, that sort of improvement is not expected soon on Unix.

As previously mentioned, security of individual files tends to be left to the users themselves or the system administrator. While an almost foolproof data-encryption algorithm used on Unix for passwords may be invoked by users to encode any file they wish, several known methods can be used to compromise both user passwords and the super-user password. The result of this compromise could be destruction of important data files and the possible dilution of the encryption algorithm. Therefore, we advise would-be keepers of sensitive information to administer Unix with care.

System resources, in terms of exclusive use of physical devices and processor and memory facilities, are not adequately protected. This means that a naive user's first C program could crash the system. Also, if a program needs a tape drive and it is not available, the program will simply fail rather than wait for the tape.

However, these failings must be weighed against some more facts: First, Unix uses much less memory than other large operating systems, needing 64K to 160K bytes of main memory for the executable kernel. Large systems may require a megabyte of memory to run, or even more. Of greater importance is the size of the source code. Written in a high-level language, Unix is manageable by one person, while assembly-language operating systems tend to need teams of programmers just to install the fixes issued each month by the supplier.

The one-time cost of Unix, to an end user, is measured in the hundreds of dollars; compare this to the multiple thousands required *per month* to license and maintain a mainframe operating system. In fact, the cost of Unix in binary form approaches that of a single-user CP/M

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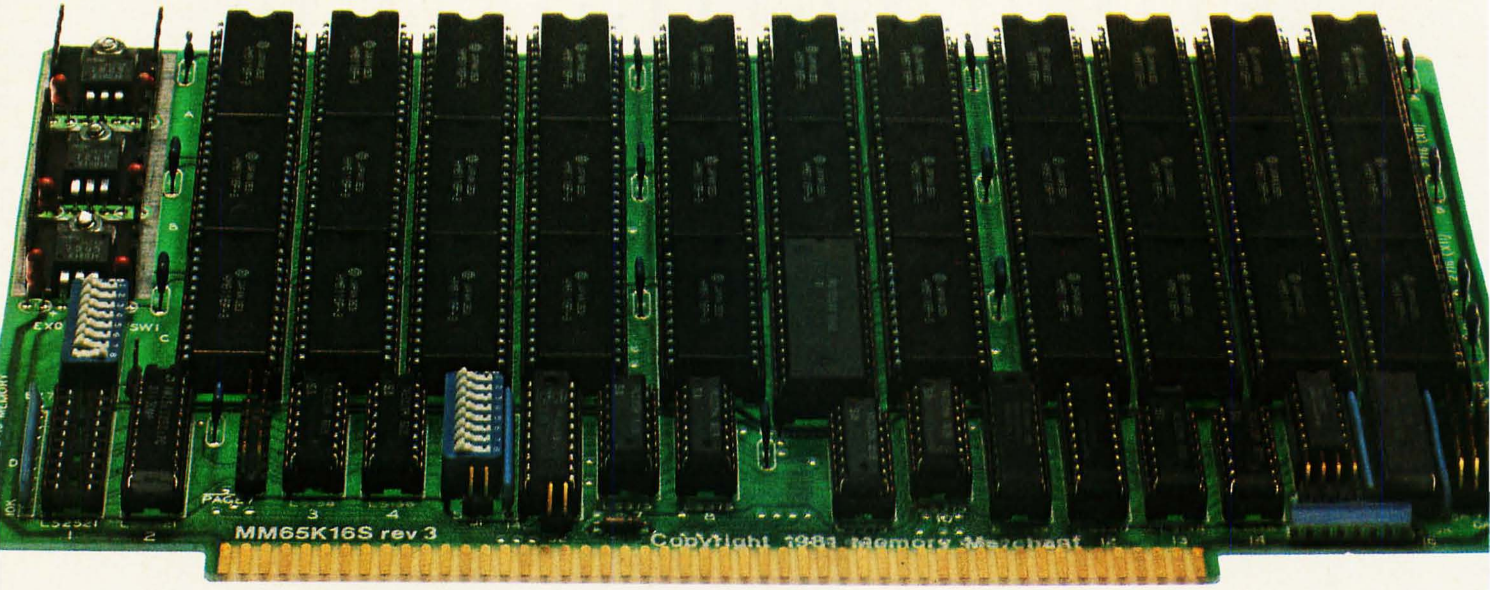

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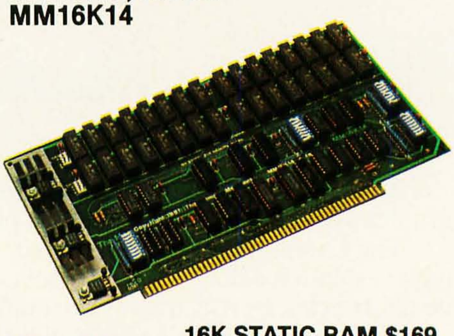

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Unix is portable, requiring from 1 to 12 months for a experienced systems programmer to move it to a different hardware configuration.

Comparing Unix to even smaller systems like CP/M is pointless because no single-user, single-tasking system is comparable to Unix on a features basis. However, important market considerations abound, which will be taken up in part 3 of this series.

Moving On

The features I've described explain why an expanding segment of the computer industry feels that Unix has reached its goal of being a pleasant environment in which to write and use programs.

Next month, I'll discuss what applications programs are available under Unix and some specific ways you can create a personalized environment on Unix. The last article of this three-part series will address Unix implementations on several different microprocessors and look at Unix in the marketplace of the future—where AT&T is likely to go with it, how it will stack up against other operating systems, and what your first Unix-based computer is likely to be.■

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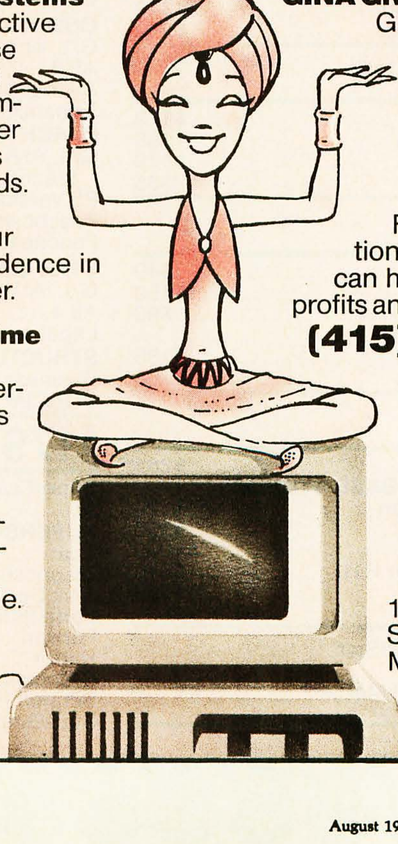

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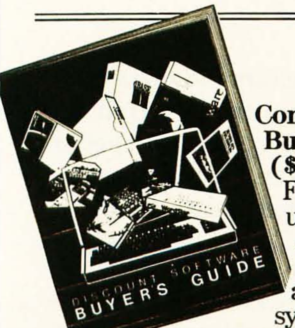

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SOFTWARE

What Is a Software Tool?

Develop your own problem-solving programming tools.

by Rebecca Thomas

The dictionary describes a tool as anything employed in performing an operation. A software tool is a program that is used to perform the operation of solving a data-processing problem. But this definition is too general for the purposes of this article because most commercial software packages would be considered software tools by this definition.

The type of software tools I'll describe here are programs that specifically aid the programmer in the development of other programs. These programs are designed to work well together.

Large programs such as operating systems and language compilers are technically software tools. In particular, the most important software tool is a good structured programming language. I'll describe how to use the Unix system and C programming language to develop software tools.

The Unix Environment and Productivity

The C programming language, the Unix operating system, and the numerous utility programs (software tools) together provide a very productive programming environment. These elements constitute the Unix development system, which promotes productivity by providing a friendly environment and quality tools for sophisticated software problem solving. The Unix system is one, and perhaps the only, operating system that actually assists in solving problems rather than presenting itself as a problem to overcome.

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Build Tools and Use Them

The most widely used Unix tools are the programs for manipulation of text. Line and screen-oriented editors create and change text, a stream editor and other utilities transform text, several programs analyze text files statistically, and powerful formatting programs produce high-quality hard copy suitable for publication.

Your first step in understanding and using software tools is to master the rich set of tools that comes with the Unix system. Then don't hesitate to build new tools as your skill increases to help with your daily programming tasks. It is often tempting to use unskilled labor (yourself included in this context) to manually perform a task instead of stopping to build a tool that automatically performs the same task. If a tool of some general utility can be built, this tool then becomes a useful addition to your ever-growing software toolbox.

The Unix Shell

A brief discussion of the Unix shell should make clear how this command interpreter can be used to manipulate the software tool utilities. The Unix shell is actually a program itself that interprets user commands, calls programs into memory, and executes them one at a time or in series.

The Unix shell can be employed interactively as a command language to provide an efficient interface to the facilities of the operating system. In addition, it can be used in a "batch mode" to execute files of commands. In the latter context, the shell functions as a programming language that provides control-flow primitives (including while-do, if-then-else, for-do, and a case statement), string-valued variables, and parameter passing from the command line. I'll restrict my discussion to the interactive command language of this powerful command in-

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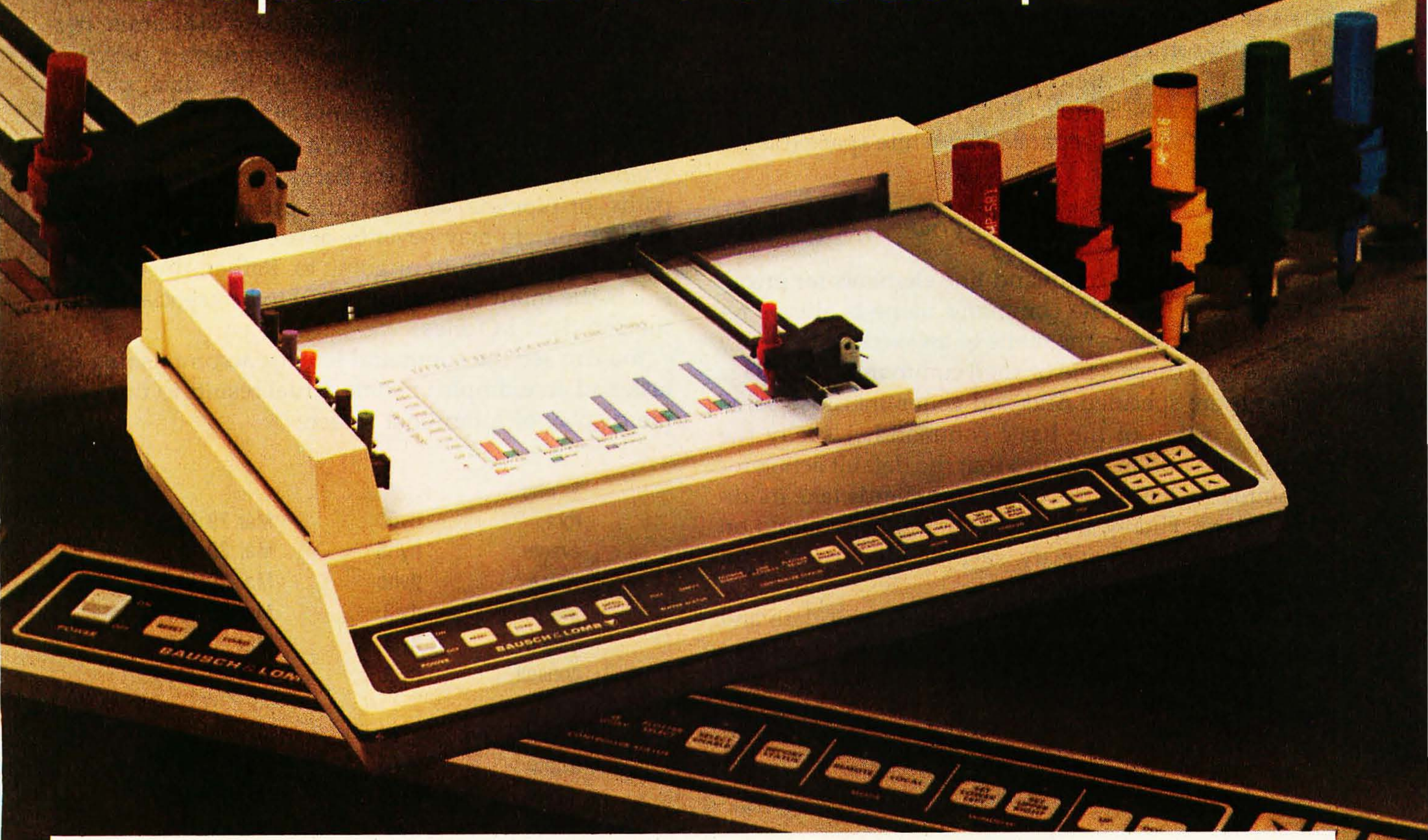

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terpreter. In some cases the algorithms proposed for a C language software tool can be tested by using the shell to execute a file of Unix commands to simulate the behavior of the algorithms. After debugging, you can code the algorithms in C.

The Unix software tools have a common invocation structure, which is based on how the shell invokes and executes programs. Simple shell commands are written as a series of "words" separated by white space (blanks or tabs):

(command name) (flags or options) (arguments)

These are three basic command-line elements for invoking a software tool. The command name is always required and represents the name of an executable binary program or perhaps a file of shell commands. The flags or options are specified next and generally cause some modifying action of the basic command. Usually the absence of an option indicates that the default action for the command is desired. Not all commands take modifying options. Finally, arguments might be required on the command line to specify, say, the identity of input or output files or devices.

Simple Unix commands such as date (print date and time) and who (who is currently logged on the system) require only that you type their name followed by a carriage return:

```
$ date
$ who
```

(Note: I will use $ as the shell command prompt for the Unix system.) Other command lines call utilities that can take options, such as du (summarize disk usage), ls (list contents of directory), ps (process status), and stty (set terminal options). For example, some command lines and their options are

$ du -s	(summary option)
$ ls -ld	(long listing as directory)
$ ps -alx	(long listing of all processes)
$ ps -l	(long listing of owners' processes)
$ stty erase '^h'	(set erase character to backspace)

Finally consider the following commands, which may require specification of file arguments: cat (catenate and display file), cp (file copy), mv (move or rename files), rm (remove file), and wc (word count). With file arguments, simple command lines are

$ cat file1 file2	(display contents of file1 followed by that of file2)
$ cp srcfile destfile	(copy contents of srcfile to destfile)
$ mv oldname newname	(rename file oldname to newname)
$ wc -l textfile	(count lines in textfile)
$ rm -i oldfile	(interactively delete oldfile with query)

Design Tools as Filters

I'll design a filter program as the first example of a software tool. In a filter program, the input data comes from the standard input file (the keyboard, by default) and output data is directed to the standard output file (terminal screen, by default). The filter program performs some suitable transformation of the data passing through. In this way, the output of any one utility program may become the input to a different program. The Unix shell will establish the necessary connection (data paths, or pipeline) between the programs. In fact, the utility program may never be aware of where its data is actually coming from or going to. Rather, the tool considers the input and output (I/O) to be associated with the standard I/O files.

You can see the command line for accomplishing the task and an example of some actual results in this sample display of a terminal screen:

```
$ who
root        tty00       Mar 29 10:30
avante      ttyh5       Mar 29 10:03
vance       ttyhc       Mar 29 10:39
avante      ttyi3       Mar 29 10:27
becca       ttyi4       Mar 29 11:01
consult     ttyi9       Mar 29 11:08

$ who | sort
avante      ttyh5       Mar 29 10:03
avante      ttyi3       Mar 29 10:27
becca       ttyi4       Mar 29 11:01
consult     ttyi        Mar 29 11:08
root        tty00       Mar 29 10:30
vance       ttyhc       Mar 29 10:39
$
```

The first example, with just the who command, has the output sorted according to the second field (terminal designation). By using the sort command, you can have the second example reorder the file by the first field (the log-in name).

This use of filter tools necessitates restriction of program output to a bare minimum. For example, the who command produces one line of output for each user logged in to the Unix system. Thus, to obtain just the number of users, pass the output of who into the input of wc, the word count program employing the option to just count lines of input:

```
$ who | wc -l
6
$
```

If the who command output included a header containing the date and time, column headings, etc., more information would be at hand. However, then the number of output lines would no longer directly reflect the number of users. Instead it is best to use other utilities

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such as date to obtain additional information independently of the who program.

A Software Tool Performs One Job Well

You should design each software tool to perform a specific task as well as possible. If a different task is to be performed then a different tool (program) should be developed. This approach helps to avoid the messy "Band-Aid" program, which may be the result of adding too many new features to an existing software tool. For example, the Unix C compiler doesn't have any output listing. Instead, you would use other programs (tools) to generate symbol tables, etc.

It may not always be obvious how to best interpret the "one-task-well" guideline. For instance, programmers frequently require a source-code listing containing a line number at the beginning of each line. Here, the question might be raised, should another option be added to an existing tool such as cat to produce line numbering or should a dedicated line-numbering filter be developed? The best answer may depend in part on the tools that already exist and the best method of incorporating the line-numbering utility into the system.

Design for Early Testing

Design the software tool, no matter how complicated, so that some or all of it can be tested early in the design cycle. It would be advantageous if this first testing phase could begin within a few weeks of starting a project. In this way, you will spot algorithms that do not work as expected early so that they can be changed or even discarded. It is often prudent to discard awkward code and start over with a fresh approach based on the design experience to date.

Coding Guidelines

The tool program should be broken down into modules of code, which help simplify a program development task by controlling its complexity. Some coding guidelines are as follows:

- Use the logical control structures that the C language provides instead of the goto statement.
- A function should be moderate in size (say, less than 100 lines long and preferably smaller). This is so that the function can be easily comprehended as a whole.
- The functions that make up the module should be closely related, and the resulting module should represent one functional unit of the program.
- Both the functions and modules should be as independent of each other as possible. In this way, a change in one function or module of code will have minimal effect on other functions or modules. If it is necessary to share, for example, data structures between modules, then the interface to these structures should be clearly visible and well defined. In this way, the program will be easier to change at a later date.
- All the programs should be designed to work together so that a complicated task can be solved by suitably combining existing programs. In this context each program appears as a module, which interfaces with other programs via a simple well-defined interface.

Write code that is as clear and simple as possible and still does the job. The C language code, especially, may be written in a very obtuse, terse manner, which makes it almost incomprehensible. Such an algorithm could probably be expressed simply. Obviously, the simple approach is more desirable because other programmers (or you) may be called upon to maintain or modify your programs.

Build the program in steps that are manageable. Develop the central theme first, leaving the embellishments for later. In this way, the portion that is constructed first can be tested and even used in a production sense as soon as possible.

Don't reinvent the wheel. That is, if possible, start with existing modules or programs, modifying them as desired.

Portable Tools

You should design the software tools to be portable. To help achieve this end, the interface to the operating system should be clearly defined and localized within

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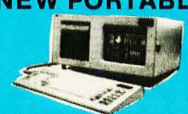

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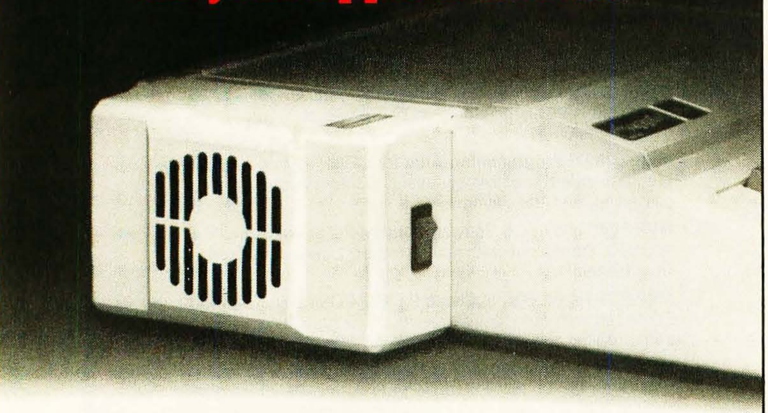

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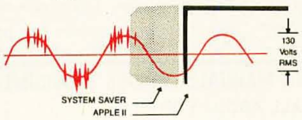

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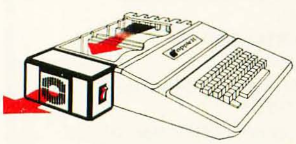

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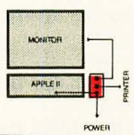

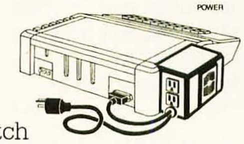

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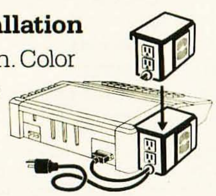

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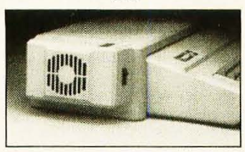

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Listing 1: *The file copy filter program,* copy. *Written in the C language, the program uses Unix I/O routines to transfer data a character at a time from the keyboard to the terminal screen.*

```
$ cat copy.c
#include <stdio.h>
main()
{
        int c;
        while ((c = getchar()) != EOF)
                putchar(c);
}
```

the code. For example, if you use input and output routines from the Unix standard I/O library, then portability between Unix systems is virtually guaranteed. Even if the software tool is to be written for a non-Unix environment, you should restrict all code that interacts with the operating system to a minimum number of modular functions.

Primitives

For the purposes of this article a primitive is code that deals with the interface between the software tool and the operating system environment. You may use primitives to enhance portability of the software-tool program by restricting all system-dependent code to a few modules. In this way, only the system-dependent primitives need to be rewritten when moving the tool program to a foreign programming environment.

File Copy Filter

The trivial-looking example in listing 1 provides the basis for the tool programs I'll discuss. (For this and the examples that follow, I'll use the standard I/O library from the Unix environment. If you are working in a different environment, use the equivalent basic primitives for I/O.) Basically, the copy program transfers data a character at a time from a standard input file (the keyboard, by default) to a standard output file (the terminal screen, by default). I am employing two primitives from the Unix standard I/O library: getchar( ), which reads the next input character, and putchar(c), which outputs a single character. In listing 1, the line #include <stdio.h> directs the C compiler preprocessor to add the standard I/O library definitions directly to the source file before actual compilation begins.

Note that c is declared as an integer. This is necessary in order to have an end-of-input code, EOF=−1 in this case, which is distinct from any valid character value. Also note that the standard library routine getchar( ) actually returns an integer value.

I/O Redirection

The Unix shell maintains three open files for each program it invokes: the standard input file, the standard output file, and a standard error file. Recall that this basic file-copy program reads characters from the standard input file and writes them to the standard output file. The Unix shell can be easily instructed to redirect input

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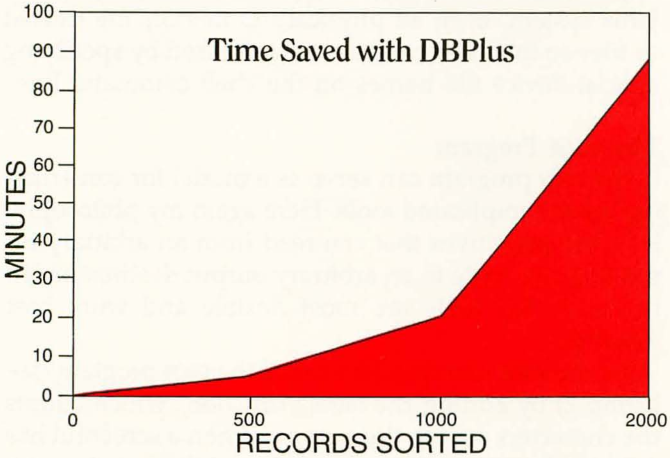

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and/or output for the copy program. This redirection capability of the shell greatly enhances the utility of a program even as simple as copy.

The shell redirects input or output by closing the original standard input and/or output file and opening the other files specified on the command line in its place. In this way, the program that the shell invokes is completely unaware of the redirected input or output.

For example, assume you want to quickly put a few lines in a disk file named message. The invocation command line would be

```
$ copy >message
```

Characters entered from the keyboard (standard input) would be written to the disk file message. When text entry was complete, the operator would give the end-of-file code (a Control-D in Unix), and the copy program would exit. Input could also be redirected. In fact, you could check the contents of the file you just created by rechanneling input from the disk file message instead of the keyboard. Here the command line would be

```
$ copy <message
```

The contents of the disk file are read by copy and sent to the terminal screen (standard output file).

The shell can redirect both input and output simultaneously so that copy could be used to easily produce another instance of the disk file message as a backup. For example:

```
$ copy <message >message.bak
```

Now you have seen how a program as simple as copy is quite useful in its own right. You have also seen that with the aid of the Unix shell this program can be used to copy a character stream from virtually any source to any destination (if it can be specified as a file). In the Unix system, even all physical I/O devices are treated as files so that they can be easily accessed by specifying special-device file names on the shell command line.

The page Program

The copy program can serve as a model for constructing more complicated tools. Here again my philosophy is to use primitives that can read from an arbitrary input and can write to an arbitrary output destination. In this way, the tools are most flexible and work best together.

For the next example, let's create the page program (see listing 2) by adding the more( ) function, which counts the characters sent to the output. When a screenful has passed, the output is suspended, and the function command( ) is called, instructing the program to await operator intervention. If the operator presses the space bar, another screenful will be displayed, or if the return key is pressed, only one additional line will be shown. Obviously, this simple program lacks many embellishments required for a production version; however, it does serve to illustrate the evolution of a more complex tool from a simple one.

The page program requires an additional I/O channel (open file) to be attached to the keyboard. Thus the statement

```
20      fd = open("/dev/tty", 0);
```

returns a file descriptor for reading the terminal (/dev/tty). If the standard input channel is used for all input (including the operator response to the query for "more?"), then the display would never stop after one screen or line because the answer to the query would be supplied by the file passing through the filter.

The function command( ) reads characters from the alternate keyboard input shown opened in line 20 of listing 2 as depicted by the statement

```
48      while (read(fd,&c,1) && c != ' ' && c != '\n' && c != EOF)
49
```

This statement causes a character to be read into the location pointed to by &c. If the character is not a space (' '), a newline ('\n') or EOF (the end-of-file code, −1), then it will remain in the while loop. A space character causes the line counter to be reset so that another entire screenful will be displayed, as follows:

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Text continued on page 236

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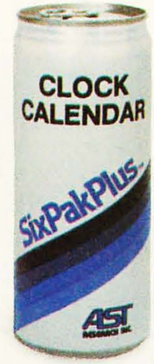

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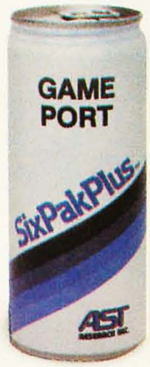

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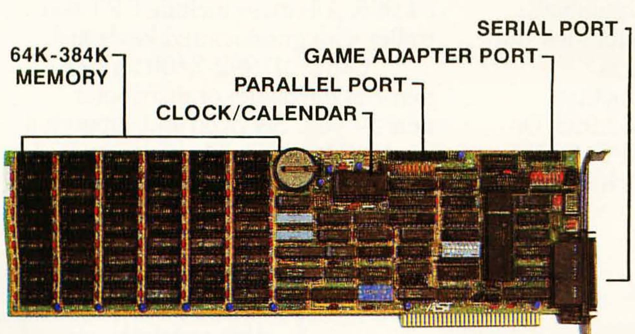

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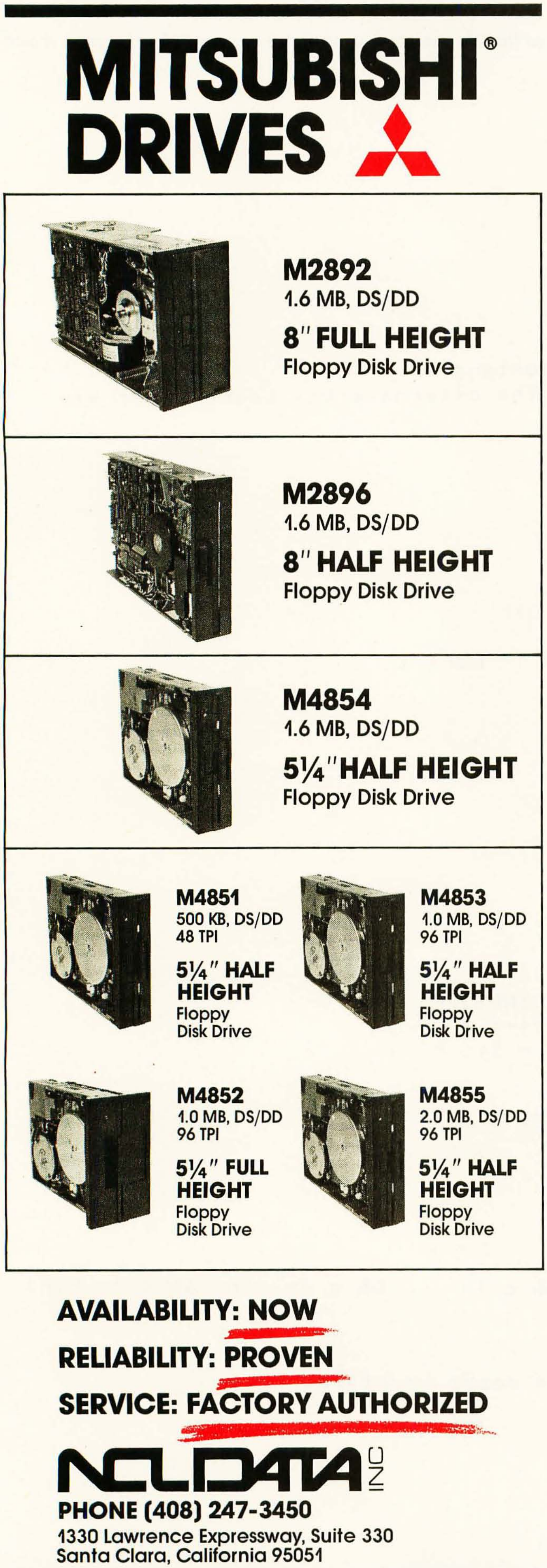
Listing 2: *The* page *program counts the characters sent to the output so that the operator can control the amount of information shown on the terminal screen.*

```
$ cat -n page.c
     1  #include <stdio.h>
     2  #define LINESIZE 80
     3  #define SCRNSIZE 23
     4
     5  /*
     6   * Global variables:
     7   */
     8
     9  int c; /* The character */
    10  int colcnt, linecnt; /* The counters */
    11  int fd; /* The descriptor for the alternate key board input */
    12
    13  main(argc, argv)
    14  int argc;
    15  char **argv;
    16  {
    17          colcnt = 1;
    18          linecnt = 0;
    19
    20          fd = open("/dev/tty", 0);
    21
    22          while ((c = getchar()) != EOF) {
    23                  putchar(c);
    24                  more();
    25          }
    26  }
    27
    28  more()
    29  {
    30          if (c == '\n') {
    31                  linecnt++;
    32                  colcnt = 1;
    33          }
    34          else {
    35                  colcnt++;
    36                  if (colcnt == LINESIZE) {
    37                          linecnt++;
    38                          colcnt = 1;
    39                  }
    40          }
    41          if (linecnt == SCRNSIZE)
    42                  command();
    43  }
    44
    45  command()
    46  {
    47
    48          while (read(fd,&c,1) && c != ' ' && c != '\n' && c != EOF)
    49                  ;
    50
    51          if (c == ' ')
    52                  linecnt = 0; /* reset counter */
    53          else if (c == '\n')
    54                  linecnt--;
    55          else
    56                  exit();
    57  }
$ []
```



Text continued from page 230:

```
                if (c == ' ')
                        linecnt = 0; /* reset counter */
```

Actually, because Unix usually requires you to type the line terminator before the keyboard is "read," a space followed by a carriage return must be typed to get the next screenful.

A *newline* is the Unix line terminator and is more or less equivalent to the CP/M's carriage return/linefeed pair. When the response to the "more?" query is a newline (entered by typing the return key), one additional line will be displayed because the line counter is decremented by one:

```
                else if (c == '\n')
                        linecnt--;
```

The remaining possibility has to be the EOF code, which causes the page to exit:

```
        else
                exit( );
```

The concat Program

For the last example, I will introduce a few more primitives and illustrate how to transform the copy program into a more general utility, called the concat program, which can be employed to combine files specified on the command line and send them to the standard output (see listing 3).

In this example, I have added the function getarg( ), which returns a pointer to the desired command-line argument. This approach is necessary so that functions besides main( ) can access the command-line variables without having to pass these same variables as additional arguments to functions outside of main( ). Note that you need the function allocarg( ) to allocate space for the command-line argument(s). The actual copy operation is performed by filecopy( ), which will copy the contents of the files (if specified) to the standard output file. If no files are designated on the command line when concat is invoked, then concat acts like the copy program introduced earlier.

Line 19 of listing 3 declares the variable fp to be a pointer to type FILE and fopen( ) to be a function that returns a pointer to a FILE. Now just what is FILE? First consider the definition of the array of _iobuf structures as defined in the include file <stdio.h>, which is actually located in /usr/include/stdio.h:

```
extern struct _iobuf {
    char   *_ptr;    /* next character position */
    int     _cnt;    /* number of characters left */
    char *_base;     /* location of buffer */
    char   _flag;    /* mode of file access */
    char     _fd;    /* file descriptor */
} _iob[_NFILE];
```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Listing 3: *The* concat *program. Building upon the original* copy *program, this expanded utility program can combine files and send the results to the standard output, in this case the terminal screen.*

```
$ cat -n concat.c
#include <stdio.h>

/*
 * Command line arguments must be
 * external to all functions:
 */

int nargs; /* number of arguments */
char **argstr; /* pointer to argument string */

extern char *getarg();

main(argc, argv)
int argc;
char **argv;
{
        int i;
        char *string;
        FILE *fp, *fopen();

        allocarg(argc, argv);

        if (nargs == 1)
                filecopy(stdin);
        else
                for (i = 1; i < nargs; i++) {
                        string = getarg(i);
                        fp = fopen(string, "r");
                        filecopy(fp);
                        fclose(fp);
                }
}

allocarg(argc, argv)
int argc;
char **argv;
{
        int i;
        char *calloc(), *malloc(), *strcpy();

        nargs = argc;
        argstr = (char**) calloc((unsigned) argc, sizeof(char*))

        for (i = 0; i <argc; i++) {
                argstr[i] = malloc((unsigned) strlen(argv[i])+1)
                strcpy(argstr[i], argv[i]);
        }
}

char *getarg(n)
int n;
{
        if (n > nargs)
                return((char *)-1);
        return(argstr[n]);
}

filecopy(filein)
FILE *filein;
{
        register int c;

        while ((c = getc(filein)) != EOF)
                putc(c, stdout);
}
```

The include file further defines FILE to be an instance of this structure:

```
#define FILE struct _iobuf
```

Observe that the structure _iobuf contains information important to performing buffered I/O (also known as stream I/O). For instance, information such as the buffer location, the current character position in the buffer, the mode of file access (read/write), and the actual (low-level) file descriptor (which was used in the page program) is contained in this important structure.

Note that all names in the include file stdio.h intended for internal use begin with an underscore (_) to minimize the chance of conflict with user-defined names. Some of the important names intended to be used externally are

stdin	(&_iob[0])	the standard input file (fd = 0)
stdout	(&_iob[1])	the standard output file (fd = 1)
stderr	(&_iob[2])	the standard error file (fd = 2)
EOF	(−1)	end-of-file value
NULL	(0)	the null pointer
BUFSIZ	(512)	recommended I/O buffer size

FILE is a convenient shorthand for declaring pointers to streams. Streams represent buffered I/O with output flushing where necessary.

The main processing loop for the concat program is reproduced here:

```
26    for (i = 1; i < nargs; i++) {
27          string = getarg(i);
28          fp = fopen(string, "r");
29          filecopy(fp);
30          fclose(fp);
31    }
```

For each command-line argument, (for i = 1; i< nargs; i++), a pointer to that argument, string = getarg(i), is obtained. The string argument represents (you hope) a file that is opened for reading (fp = fopen(string, "r"). The function filecopy( ) actually performs the copying from the designated file to the standard output (see lines 63 and 64 in listing 3).

The allocarg( ) function is required to allocate storage for the external variables nargs and argstr. The Unix library routine calloc( ) allocates memory for an array of argc elements of size size of(char*). The malloc( ) routine returns a pointer to a block of at least strlen(argv[i]) + 1 bytes beginning on a word boundary. The strcpy( ) function actually makes the copy of the argument to the external variable argstr.

This last example nicely illustrates how the addition of a few primitive functions can transform the basic copy program into a very useful general-purpose tool with many of the same properties as the Unix cat utility program.

Summary

The software tools I've used as examples are very simple, but their design typifies the ease of use of the Unix environment. By carefully developing your software tools and adhering to good programming practice, you can design your own problem-solving tools. With these tools, you, the programmer, become the hammer rather than the anvil.■

Dr. Rebecca Thomas (1839 10th Ave., San Francisco, CA 94122) is coauthor of the popular Unix guide for beginners, A User Guide to the Unix System *(Osborne/McGraw-Hill, 1982). She is also coauthoring additional Unix titles to be available in 1983, including both a business user's and an application programmer's guide to both the Unix and Xenix systems, to be published by Addison-Wesley.*

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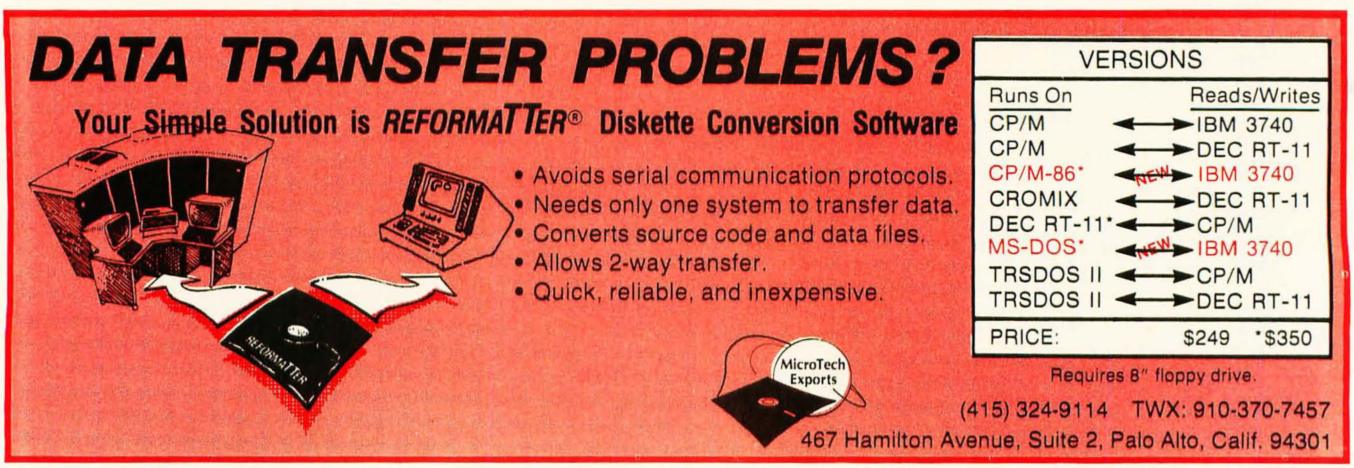

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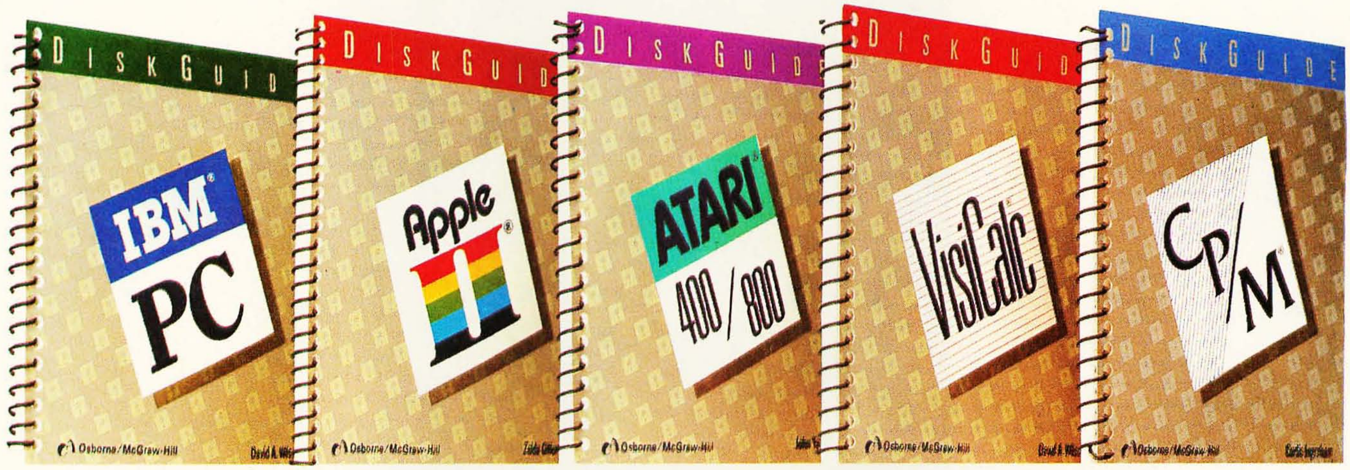

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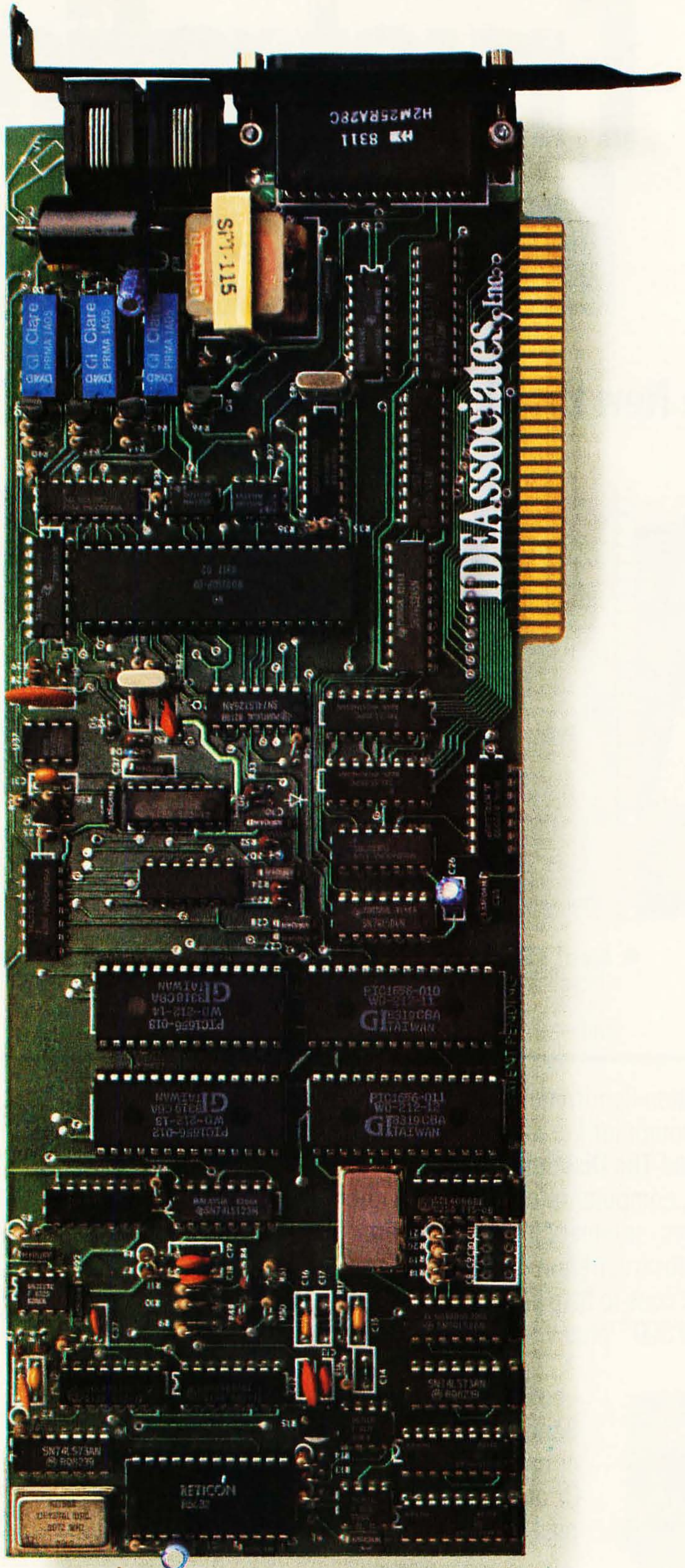

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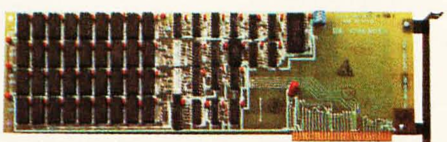
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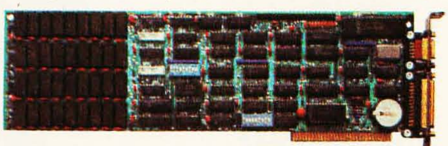
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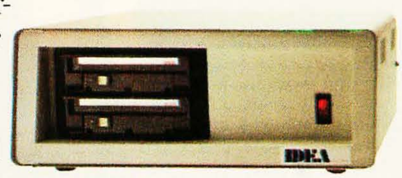

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The Unix C Compiler in a CP/M Environment

What subset of Unix version 7's compiler makes sense for CP/M?

by Matthew Halfant

How much of the C programming language, as it exists under Bell Labs' version 7 Unix, can be made available under CP/M? To begin with, we must say what distinguishes Unix C from other implementations that follow the formal language definition. This is largely a matter of the "standard I/O library," though I maintain below that other groups of support functions must be considered as well. An examination of three C compilers for the CP/M environment (small-c, BDS C, and Aztec C) will give an idea how close the compilers actually come to version 7's C.

The Formal Side of C

For those without access to a Unix system, the principal source of information on C is the remarkable book *The C Programming Language* by Kernighan and Ritchie, referred to hereafter as simply K&R (see the references). I assume the reader to be familiar with this work. Appendix A of this book contains a formal definition of C, which is the place to turn for precise specifications of syntax, scope of identifiers, and other legal matters. This is not, however, the place to resolve a question on, say, the procedure for opening a file.

C does not specify the system interface: there are no built-in connections with terminals, printers, or files. These functions are supplied as library routines rather than innate parts of the compiler. Presumably, this simplifies the task of writing the compiler and allows flexibility in constructing the I/O (input/output) interface. But it creates a potentially awkward situation: programs will not be portable between systems with widely divergent support libraries.

For this reason, Unix supplies the *standard I/O library* that is, according to chapter 7 of K&R, ". . . a set of functions designed to provide a standard I/O system for C programs . . . the routines are meant to be 'portable' in the sense that they will exist in compatible form on any system where C exists, and that programs that confine their system interactions to facilities provided by the standard library can be moved from one system to another essentially without change."

Adoption of this library is not obligatory; we have the example of Whitesmiths' C compiler, in which most of the standard functions have been renamed or redefined. The difficulty observed in moving a Whitesmiths program to a Unix system argues for formalizing the standard I/O library along with many other of the common functions described in K&R. (Editor's note: Whitesmiths recently released a new version of its compiler that will be more compatible with Unix version 7.) Such a project is the responsibility of the ANSI (American National Standards Institute) committee that was recently formed. I am not attempting to define a language standard here but merely describing the dialect of C that is spoken on Unix systems and devoting special attention to the subset that can be implemented under CP/M.

In the remarks of Kernighan and Ritchie quoted above, the terms "standard library" and "standard I/O library" are used interchangeably, whereas I would prefer "standard library" to designate the entire collection of support functions, of which the I/O library is a specific subset. Other members include the string-handling functions (strcat( ), etc.), the math library (sqrt( ), etc.), and a number of system calls. Some such collection of functions must be standardized if convenient portability is to be secured.

The Standard Library as Part of the C Language

To illustrate the importance of standardization, compare the treatment of character strings in C versus those in PL/I. The latter admits strings as a data type that may be assigned, transmitted as an argument, or returned by a function. In C, strings are implemented as null-terminated character arrays. Suppose I want to write a utility function to remove blanks from a string. I want to turn "this is a string" into "thisisastring". One strategy (I don't claim it to be optimal) is to operate in what might be called a "while there's still a blank in the string" loop in pseudocode. The loop body locates the leftmost blank, breaks the string into the part before the blank and the part after, and concatenates the two parts. In PL/I, I might write

```
do while(index(string,' ')>0);
```

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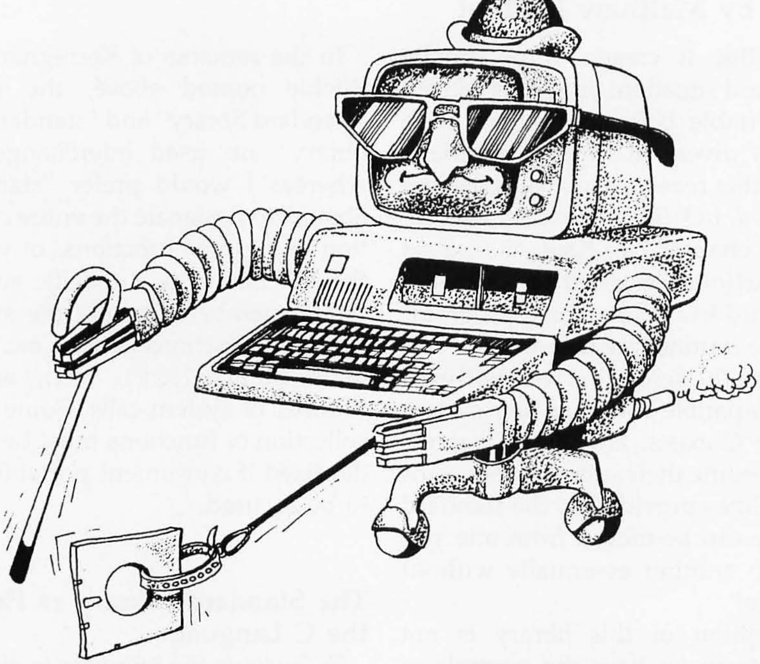

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```
i = index(string,' ');
string  =  substr(string,1,i-1) ||
    substr (string,i+1);
end;
```

The concatenation operator || is part of the PL/I language, as are the "built-in" functions index( ) and substr( ).

In C I would use a similar method but would use the standard library functions index( ) (modeled on the above) and strcat( ):

```
while( (p=index(string," ")) != NULL) {
    *p++ = "\0";
    strcat(string,p);
}
```

Concatenation is achieved with a function call; assignment, when required, is done the same way (using strcpy( )). As a C programmer, I come to regard functions like index( ) and strcat( ) as parts of the language, as is the case with their PL/I counterparts. Of course, they are not really parts of C as defined in Appendix A, but they do belong to Unix C, and I would expect to find them accompanying any C compiler advertised as Unix version 7 compatible.

What Is Meant by "Unix C"?

My intention is to use the phrase "Unix C" suggestively, rather than definitively, to encompass those features commonly used by C programmers in the Unix environment. To me, the Unix environment involves more than the union of C and the Unix standard library; it also includes certain system interface conventions, such as I/O redirection and the handling of command-line arguments. Such conventions become as indispensable as the standard library itself; thus, we begin our programs with

```
main(argc,argv)
int argc;
char *argv[ ];
{
```

and take advantage of getchar( ) and putchar( ) when writing filters that can be tested at the terminal before being applied to files or embedded in a pipe.

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Where Is the Standard Library Defined?

K&R explicitly decline to describe the standard library in its entirety; moreover, several of the functions illustrated in the text differ in minor ways from those currently used. For example, the memory allocation function alloc( ) is named malloc( ) in version 7 Unix. A less trivial departure concerns the function index( ): as shown on page 67 of K&R, it returns the integer index of the located substring (or -1 if none is found); under Unix version 7, index( ) returns a pointer to the located substring (or NULL if none is found). There are other inconsistencies of this kind.

The authoritative source for standard library definitions is Volume 1 of *The Unix Programmer's Manual*, which has recently been published in book form (see the references). This volume is divided into several sections, of which the ones on system calls (section 2) and subroutines (section 3) are relevant here. They enumerate the functions that may be invoked from within a C program, and thus comprise what I would speak of as the "standard library."

The special set of subroutines normally known as the "standard I/O library" consists of those items in section 3 denoted by the letter S, as in SCANF(3S). A separate description of the standard I/O library can be found in Volume 2 of *The Unix Programmer's Manual*, a companion volume to the one mentioned above. Chapter 17, on Unix programming, is a tutorial along the lines of chapter 8 of K&R, but it covers additional ground. An appendix to that chapter, titled "The Standard I/O Library," contains a list that differs slightly from the conventions of Volume 1. For example, the listed function system( ) is not considered part of the I/O library in Volume 1. The same is true for the memory-allocation functions (see MALLOC(3)); what's more, the Appendix uses the name cfree( ) in place of free( ).

Sections 2 and 3 Seen as One Collection

Any operating system defines the interface that programmers must use in accessing system resources. For Unix, these are the system calls of section 2; they are analogous to the BDOS (basic disk operating system) calls of CP/M. The subroutines of section 3 provide a higher level of service to applications programs and are considered distinct from the system calls (by the systems programmers, at least). But this distinction, however relevant in the Unix domain, completely evaporates when we consider transporting the functions to CP/M, for they must there be implemented as subroutines based on CP/M's own system interface.

Consider an especially important example: the low-level I/O interface. CP/M's view of reading and writing files is based on 128-byte logical sectors. Unix supports a more flexible approach: there are system calls to seek to an arbitrary byte boundary, and there to read or write an arbitrary number of bytes. These functions—lseek( ), read( ), and write( )—can indeed

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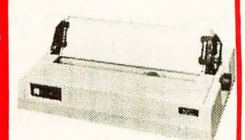

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be replicated under CP/M, but there they are higher-level functions on an equal footing with any member of the standard library.

What Portions of the Standard Library Make Sense for CP/M?

Browsing through the available functions can help us to assemble a wish-list for CP/M. Naturally we can omit functions that deal with process management, such as fork( ) and wait( ) (described in chapter 17 of Volume 2). We can also dispense with functions—such as mknod( ), for making new directories—that address incompatible aspects of the file systems. At the other extreme are functions whose suitability is clear, and we take these up before proceeding to the gray area between.

The I/O library: The standard I/O library is first on the list of things to include. (An exception, POPEN(3S), pertains to process communication and is therefore inapplicable.) Along with these subroutines, I am in favor of including the low-level functions open( ), creat( ), lseek( ), read( ), write( ), close( ), and unlink( ). This set is more convenient to use for byte-random access to binary files than are the buffered functions fread( ), fwrite( ), and fseek( ); and, fopen( ), unlike open( ), does not provide access for both reading and writing at one time. Besides, unlink( ) is needed in any case.

The mathematics library: The mathematics library can, of course, be included. This consists of double-precision trigonometric, logarithmic, exponential, and hyperbolic functions as well as the less familiar Bessel functions. The function pow(x,y) is equivalent to exp(y*log(x)) and compensates for C's lack of the exponentiation operator that in FORTRAN allows writing simply x**y. Some lower-level functions are also convenient to have, such as frexp( ) and ldexp( ), which provide separate access to the significand and exponent of doubles.

String and Character Handling

Many programmers who could live without the mathematics library would not accept omission of the string functions, strcat( ), strncat( ), index( ), rindex( ), and so on (see STRING(3)). Note that, as already indicated, some of the definitions do not agree with those given in K&R.

The character-classification macros —isalpha( ), isupper( ), and so on—are normally provided in the include file <ctype.h> (the angle brackets specify a standard directory in which include files are normally found). I find no mention of toupper( ) and tolower( ) in Volume 1, although they are included in the cited appendix of chapter 17, Volume 2 (and are, indeed, present in ctype.h). Actually, these functions are somewhat troublesome because their original formulation is, taking the first for illustration,

```
#define toupper(c) ((c) + 'A'-'a')
```

which mutilates nonletters and must normally be preceded by the test

```
if (isalpha(c)) . . .
```

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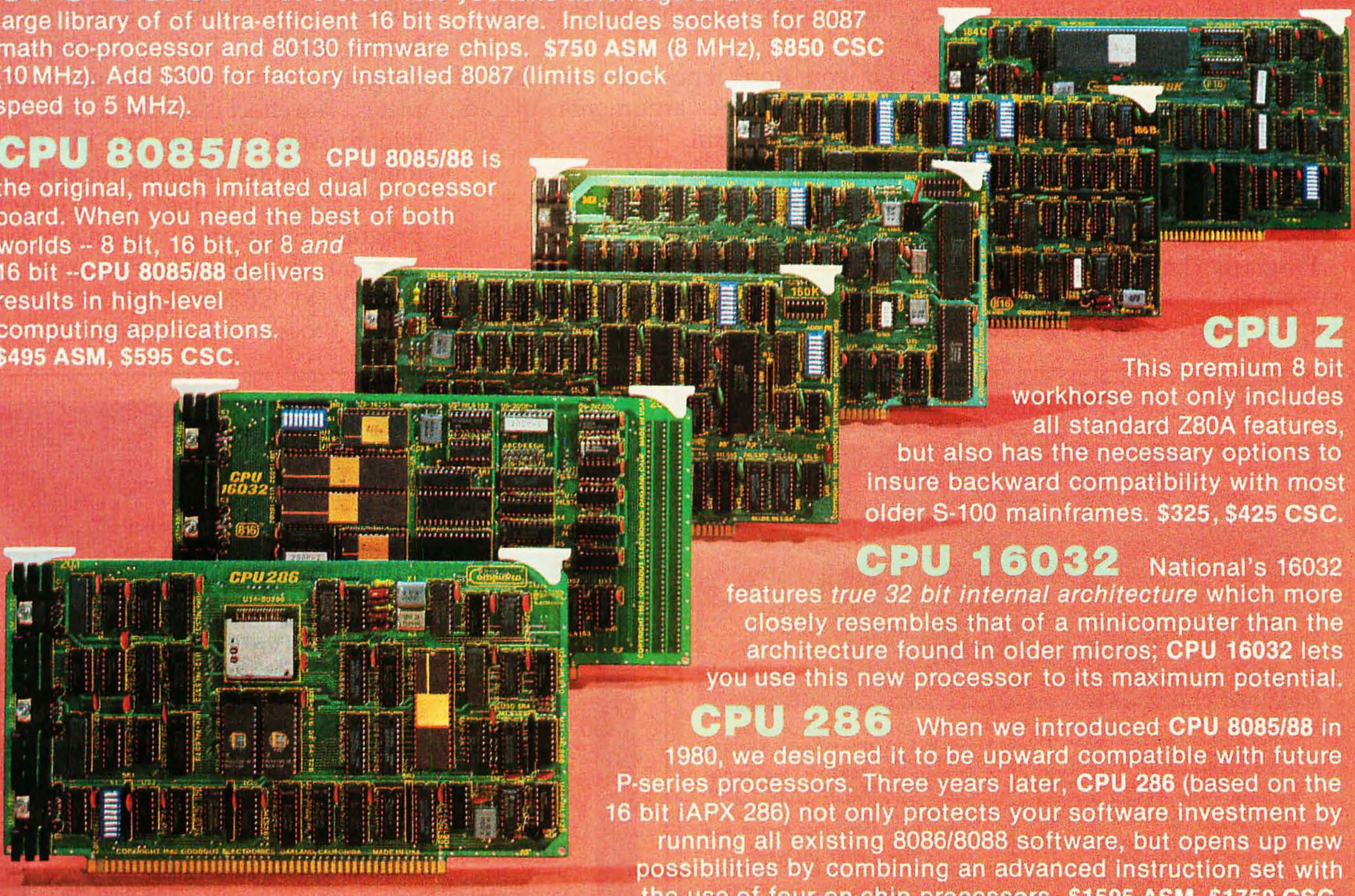

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A common, though questionable, practice is to alter the definition to incorporate the test:

```
#define toupper(c) ((c)>='a' && (c)<='z' ?
   (c) + 'A'-'a' : (c))
```

Of what I've seen, only the Code Works Q/C version 2.0 compiler retained the original toupper( ) and tolower( ) and added new functions chupper( ) and chlower( ), which do the right thing.

Memory allocation, program exit: The memory-allocation functions—malloc( ), free( ), sbrk( ), etc.—appear to be as natural under CP/M as under Unix. Most of the implementations I've seen are based on the one worked out at the end of K&R, chapter 8; they adopt the names alloc( ) and free( ) given there. Another easy transplant is the function exit( ), along with its companion _exit( ), which neglects to close all open files.

Program chaining: Several Unix system calls support program chaining; of these, execl( ) and execv( ) are appropriate for CP/M. The format for execl( ) is

```
execl(name, arg0, arg1, . . . , argn, 0)
char *name, *arg0, *arg1, . . ., *argn;
```

Here name is the complete path name of an executable module; arg0 is a repetition of name as it would be typed from the default directory, and arg1 through argn are command-line arguments to be supplied to name. To quote a charming illustration (from chapter 17 of Volume 2),

```
execl("/bin/date", "date", NULL);
execl("/usr/bin/date", "date", NULL);
fprintf(stderr, "Someone stole 'date' \n");
```

If you don't know the number of command-line arguments in advance, the form

```
execv(name, argv)
char *name, *argv[ ];
```

may be used. (This is similar to the convention by which the function main(argc, argv) is itself called.) Here argv is a null-terminated array of character strings; argv[0], argv[1], . . . is the same as arg0, arg1, . . . above.

The function execl( ) is adopted by BDS C and Supersoft C, but in an incompatible form. The term arg0 (admittedly superfluous under CP/M) is omitted, and the list begins with arg1 immediately following name. An alternative would be to replace the name execl( ) with another; for example, chain( ).

The Unix "system" function: Implementing the Unix library routine system(string), which causes the system to respond as if string were typed at the command level, is a real challenge. The difficulty is in making the program resume after the call completes. The effect is similar to that obtained using overlays, but the flexibility is greater because no special preparation is required for the called program. Supposing you can achieve this much, will addressing string directly to CP/M's Console Command Processor be satisfactory, or

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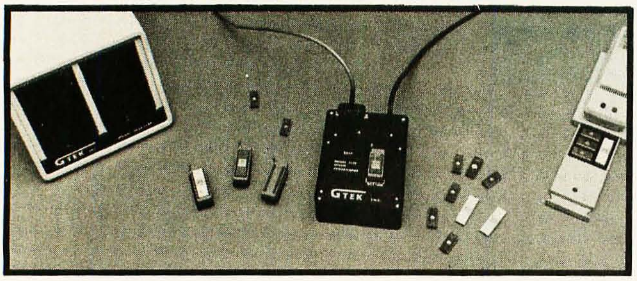

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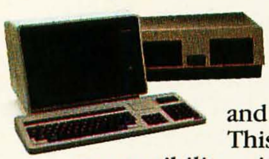

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would an intervening interpreter with sophistication approaching that of the Unix shell be preferable?

Some powerful utilities: There are some Unix utilities that are worthy of reproduction. The generic sorter qsort( ) and the random-integer generator rand( ) are examples that belong in this category and will be familiar to BDS C users. More ambitious efforts are required to duplicate the routines supporting arbitrary-precision integer arithmetic (see MP(3X)), database management (DBM(3X)), or encryption (CRYPT(3)). They'd certainly be nice to have.

It is useful to have a uniform and portable means for reading a real-time clock.

System clock: Many CP/M users employ a real-time clock (not, alas, for time-stamping files). It would be useful to have a uniform and portable means of reading such a device; the Unix approach provides a reasonable model. There are the system calls stime( ) and time( ) for setting and reading the clock; time(0) returns a long int equal to the elapsed seconds since 00:00:00 GMT (Greenwich Mean Time) January 1, 1970. Unix also provides a set of library routines for converting this to more familiar formats; for example, if t is the value returned by time(0), then gmtime(&t) returns a pointer to a structure that looks like this:

```
struct tm {
  int tm_sec;   /* 24-hour clock */
  int tm_min;
  int tm_hour;
  int tm_mday;/* day of month, 1 to 31 */
  int tm_mon;  /* month of year, 0 to 11 */
  int tm_year;  /* year - 1900, e.g. 83 for
                 1983 */
  int tm_wday; /* day of week, Sun=0,
                 Mon=1,... */
  int tm_yday; /* day of year, 0 to 365 */
  int tm_isdst; /* if !=0, daylight savings
                 time in effect */
}
```


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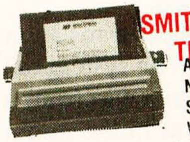

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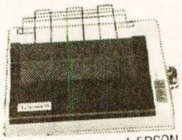

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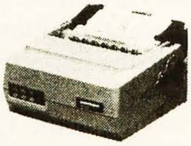

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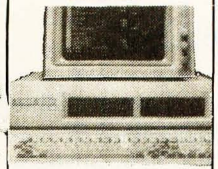

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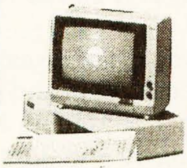

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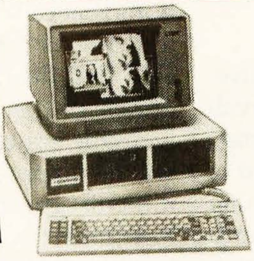

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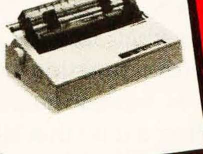

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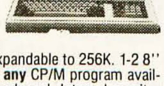

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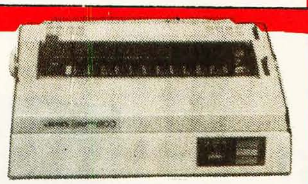

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localtime(&t) returns a pointer to a structure of the same kind, but with local time instead of GMT. Finally, the function asctime( ) accepts a pointer to a tm structure and returns a string of the form

```
Wed Apr 13 21:13:30 1983 \ n \ 0
```

It would also be nice to have available the date command (described in section 1 of Volume 1), which elicits a string in this format; or which, if typed with an argument, is used to set the system clock, as in

```
date 8304132113.30
```

which sets the date shown above. Users who do not already own a real-time clock may find time( ) and stime( ) convenient primitives, for a count of seconds can be maintained using simple hardware (or no new hardware at all, if interrupts are available). Owners of real-time clocks might prefer that localtime( ) had been the primitive function because it seems silly to have to implement time( ) by reading a date that is then converted to seconds since 1/1/1970, only to hand this back to localtime( ) to get the date again. However, the conversion to seconds is no big deal, and the transformation is a useful one to make in any case. Many interesting problems, from appointment scheduling to keeping track of the planets, involve computing the duration between two points in time; this is a far more natural operation when those points are represented as elapsed seconds from a common epoch than when they are encoded in the asctime( ) type format that is admittedly more suitable for display.

Difficulties Acknowledged

Functions like sin( ) or strcat( ) are clearly indifferent to the operating system under which they are invoked; translation from Unix to CP/M will be an issue only for functions that call on the Unix system interface. As I stated earlier, system calls that deal with concurrent processes, or that depend too intimately on the structure of the file system, will be inappropriate for CP/M. The difficult ground occurs with Unix functions for which an analogous, but not identical, service makes sense for CP/M. For example, chdir( ) changes the default directory under Unix and could be used under CP/M to log a different drive or user number. Likewise, the Unix system calls access( ) and stat( ) retrieve information about a named file and could be mapped into CP/M lookalikes. The appropriateness of doing this is partly a subjective matter; you may feel comfortable with the identification, or the analogy may seem strained by the *attempt to ignore* the underlying differences of the file systems. It is easy to state criteria for translation—the meaning of the function is preserved, and the result works well in the new environment. The hard part is judging that these conditions are met in specific cases.

An example of a bad translation might be instructive. The system call unlink( ), which deletes a file from a directory, is entirely at home under CP/M, and I adopted it without hesitation. Suppose I want to do the same with its companion call link (oldname, newname), which creates a directory entry "newname" as a synonym for the already existing file "oldname". CP/M does not allow two names for the same file, but if I get rid of the old one, then I will have merely renamed the file. Should I coerce link( ) into performing the rename( ) function under CP/M? Clearly, no. The essential idea of linking has been destroyed along with the original file name. Common practice is to coin the new function rename( ), as in BDS, Supersoft, or Aztec C.

Other Inheritances

Beyond the standard library, most of the CP/M C compilers support I/O redirection and the argc, argv convention for command-line arguments. The redirection itself is quite easy to achieve, but pipes are more trouble-

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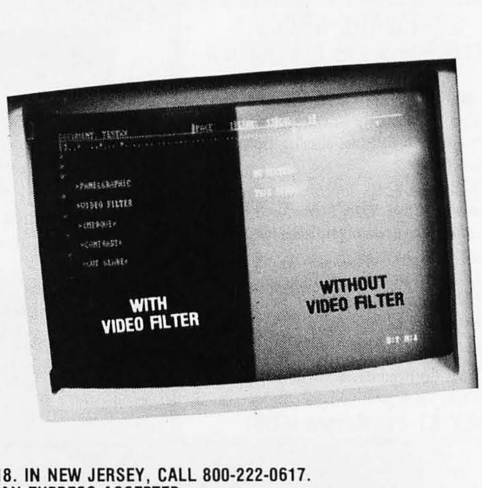

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some to implement, and only BDS C does it, so far as I'm aware. It's easiest to have each program run to completion and deposit its entire output in a temporary file, to be used as input by its successor. But a more foolproof way is to limit the output of individual programs—to avoid filling the disk—even though this adds the burden of round-robin management.

Command-line arguments are also easy to provide, except for the minor detail that CP/M refuses to let you do it! There's no legal way to capture, in argv[0], the name by which a program is invoked; thus, phrases like

```
if(argc==1) {
  printf("usage: %s filename \n", argv[0]);
  exit( );
}
```

cannot be used with CP/M. Much more annoying is CP/M's insistence on mapping its command line to uppercase; this makes it impossible to run a Unix C program in which the command-line switch -a has one meaning while -A has another.

Devices as files: One of the outstanding features of Unix is its uniform syntactical manner of addressing files and devices. Some of the C compilers, including Aztec C, support this to a limited extent: the names con:, lst:, rdr:, and pun: correspond to the logical CP/M devices so named. It is legal to open the listing device for output:

```
FILE *lst, *fopen( );
if((lst = fopen("lst:","w")) == NULL) {
  fprintf(stderr,"cannot open lst: device \n");
  exit( );
}
```

Then you can send formatted output to the printer:

```
fprintf(lst, "The square of %d is %d \n", i, i*i);
```

What is really wanted is the ability to incorporate arbitrary new devices into the file system; by writing a set of drivers and associating them with a name, I should be able to "open" the named device, read from it, and write to it using standard library functions. Further, writing the

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drivers should be sufficient; I should not be required to recompile the standard library.

This could be achieved in the following way: a standard source file, devices.c, could be used to house all device drivers, these being, for each device, the appropriate "flavor" of open( ), close( ), read( ), write( ), and lseek( ). The compiled form, devices.o, would be available on the disk for linking.

We might find, in devices.c, a structure such as the following:

```
struct dev {
  char *name;        /* device name */
  int (*open)( );    /* open function */
  int (*close)( );   /* close function */
  int (*read)( );    /* read function */
  int (*write)( );   /* write function */
  long (*lseek)( );  /* lseek function */
} dev[ ] = {
  {"plotter",pl_open,noper,pl_read,
    pl_write,noper},
  . . .
  {NULL,NULL,NULL,NULL,NULL,NULL}
    /* mandatory last entry */
};
```

The function names pl_open,. . . would be declared ahead of the structure definition. A null function, noper( ), simply returns 0 when called.

The standard library function open( ) must be written so that a given name that is neither a file name nor a CP/M device name (e.g., con:) can be associated with an external device. If the name corresponds to entry n in the device array dev[ ], the file descriptor returned by open( ) is n+MAXFD, where MAXFD is the number of file descriptors reserved for files and the CP/M devices. The search loop might appear:

```
for (i=0; dev[ i ].name != NULL; i++)
  if (strcmp(name, dev[ i ].name) == 0)
    return (i+MAXFD);
return (-1);
```

The other standard library functions, such as read( ), must know how to use this file descriptor:

```
read(fd, buf, n)
int fd, n;
char *buf;
{
  . . .
  if (fd >= MAXFD)
    return (*dev[fd - MAXFD].read)(fd, buf, n);
  . . .
}
```

Restrictions Inherent in CP/M

Beyond CP/M's mapping of command-line arguments to uppercase and its refusal to turn over the program name to argv[0], some other problems are hard to get around. Perhaps the most vexing of these is that CP/M denotes the end of a line of text by a carriage return followed by a linefeed. Unix employs just the linefeed. The problem has its origin in the teletypewriter code: the carriage return and the linefeed corresponded to physical actions on the teletypewriter; a separate newline code should denote the beginning of a new line. As it stands, both CP/M and Unix behave reasonably.

I suspect that implementers must agonize over how to handle this situation. For simplicity, consider output only: we might want to arrange for putc( ) to write a carriage-

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return/linefeed pair when given the newline argument (LF). But then putc( ) behaves improperly when we use it to write a binary file. Aztec C provides two versions of putc( ); the second version expands newline characters to carriage-return/linefeed pairs, while the first does not. In C/80, a file is opened in either text or binary mode; this determines whether newlines are given special treatment on output.

My own inclination is to avoid all special handling of the newline character: when writing '\n' to a file or device, simply write the lone character as it stands. You can always pass text files through a trivial filter that expands the newlines to carriage-return/linefeed pairs. In the case of certain devices, such as the console, the lack of expansion is a nuisance, and it would seem that you should allow drivers for particular devices to prescribe special treatment of particular characters. This is what Aztec C does for the CP/M devices con: and lst:. Alas, that interfered with my attempt to perform even low-level I/O to the lst: device (an Epson printer) for graphics control.

Actually, I like the idea of having the device drivers rather than the formatting function printf( ) (or worse yet, write( )) perform the expansion themselves. What is needed to resolve my graphics problem is simply another device name for the printer—one that exercises the same communication ports, but with a binary protocol.

A related problem occurs with detection of the EOF (end of file) condition. Under Unix, a file may contain any integer number of bytes, and it is possible to read a file down to the end using a loop such as:

```
while (read(fd, &c, 1)) {
. . .
}
```

Because read( ) returns the number of bytes actually read, a returned value of 0 signifies EOF. Under CP/M, files have physical lengths equal to some integral number of 128-byte sectors. A text file might not end on such a boundary; the CPMEOF (Control-Z) character is used to delimit the end of the file. In the unlikely event that one were reading a text file a byte at a time using read( ), it would be necessary to modify the loop shown above:

```
while (read(fd, &c, 1) && c != CPMEOF) {
. . .
}
```

Some Actual CP/M C Compilers

There are quite a few C compilers around, three of which I've used to a significant degree: small-c, BDS C, and Aztec C. Each is remarkable in its own way. They will serve as illustrations of how C has been implemented for microcomputers.

The small-c code generator produces assembly mnemonics for the 8080 but can be made to produce mnemonics for other processors as well.

small-c: small-c is a subset of the C language and was created by Ron Cain, who simply wanted a compiler for his home computer. It is described in his article "A Small C Compiler for the 8080s" (see *Dr. Dobb's Journal*, Number 45). The small-c compiler is written in small-c and is fully compatible with Unix C. It had to be; the first working version was compiled on a Unix system.

Small-c has char and int data types and pointers to each of these; there are no floats, longs, multiply-dimensioned arrays, or structures. Control statements include if, else, and while; there is no for, do, or switch. Only a subset of the operators is supported, not including &&, ||, or the assignment operators +=, *=, etc. Nonetheless, the language is clearly useful: it served to write its own compiler.

Although it was not originally intended for CP/M, a CP/M version of small-c is available from the Code Works of Santa Barbara, CA. This includes full source code for the compiler, which is in the public domain, and a run-time support library, which is copyrighted. Many extensions of this compiler have appeared, includ-

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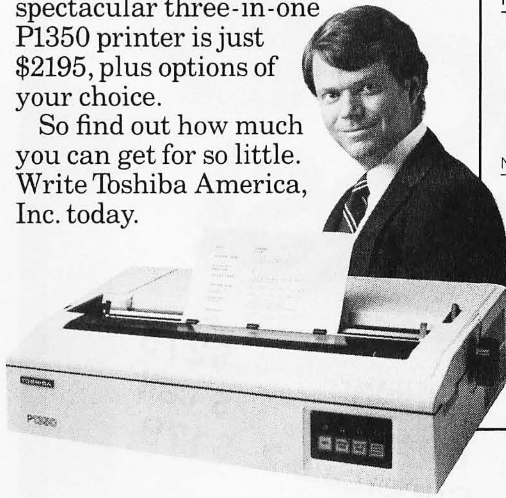

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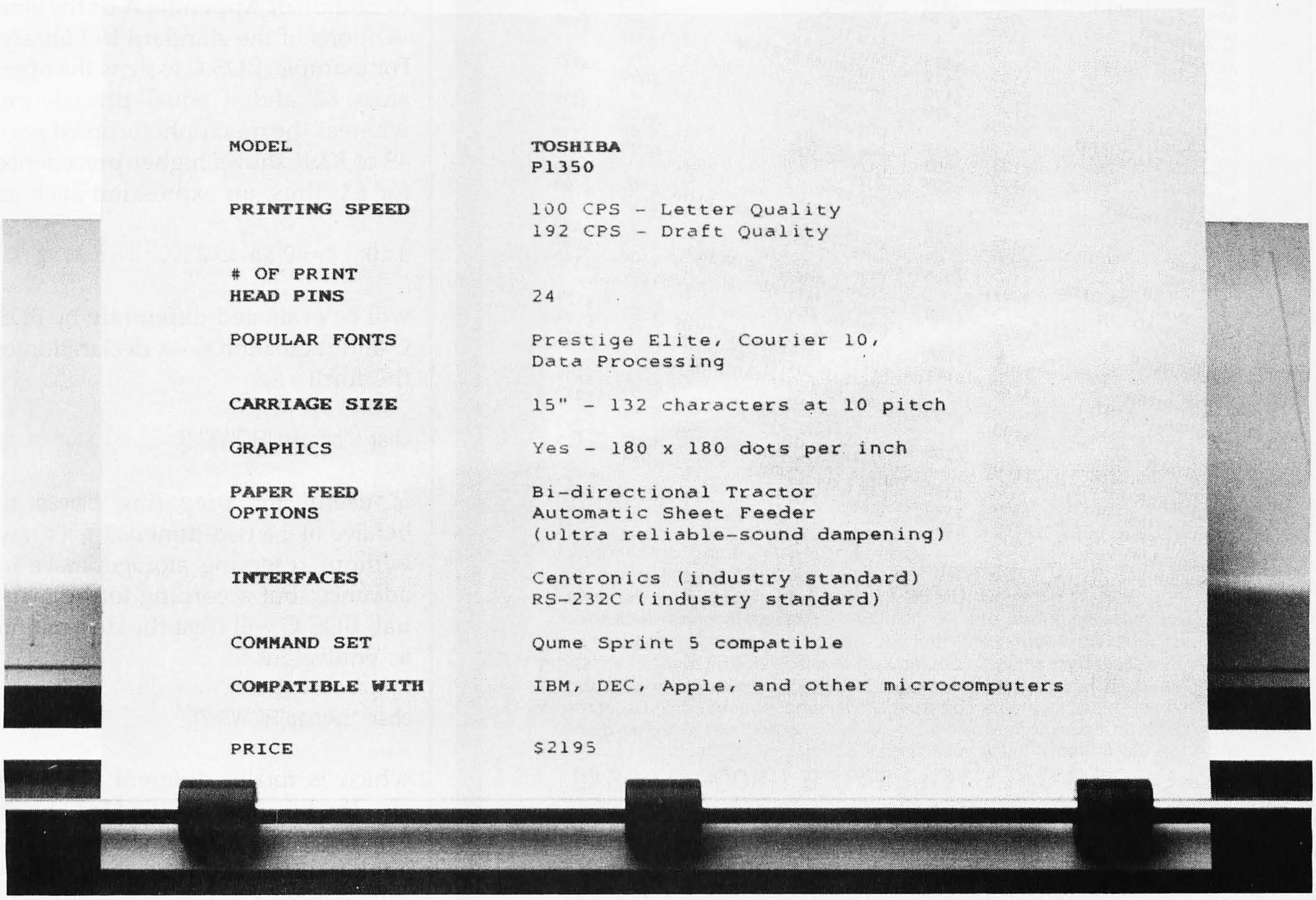

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ing C/80 by the Software Toolworks of Sherman Oaks, CA, which implements a more complete subset and produces more efficient code.

Besides providing the student an extraordinary opportunity to probe compiler internals, small-c has the advantage of being easily transported to other machines. The code generator, as written, produces assembly mnemonics for the 8080; it is a simple matter to arrange for it to produce mnemonics for other processors as well. This has been done a number of times; I did it for Texas Instruments' 9900, and my article "Small-C for the 9900" (see *Dr. Dobb's Journal*, Number 69) gives some pointers on what's involved.

BD Software C: BDS C was one of the early entries in the CP/M world and was the first (so far as I know) to adopt K&R as its guiding document. Despite this, it is not entirely compatible with either the language definition of Appendix A or the conventions of the standard I/O library. For example, BDS C assigns the operators && and || equal precedence, whereas the much-photocopied page 49 of K&R shows higher precedence for &&; thus, an expression such as

```
a<b || c==0 && d>2
```

will be evaluated differently by BDS C and regulation C. A declaration of the form

```
char (*bitmap)[ROWSIZ];
```

is useful for preparing bitmap to behave like a two-dimensional array without reserving storage space in advance; but according to the manual, BDS C will treat the declaration as equivalent to

```
char *bitmap[ROWSIZ];
```

which is totally different. There is also the business of standard library functions like fopen( ) and read( ) behaving differently than their identically named K&R counterparts.

These incompatibilities, while unfortunate, are not severe; with modest effort, a BDS C program can be converted to run under Unix.

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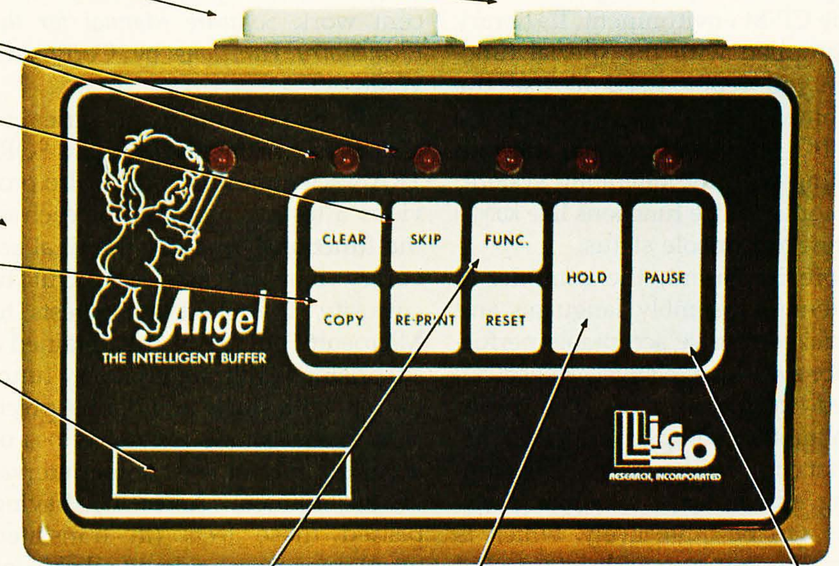

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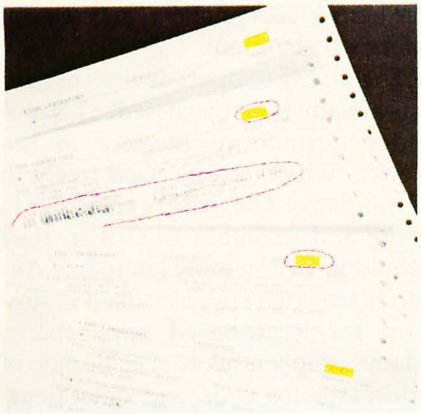

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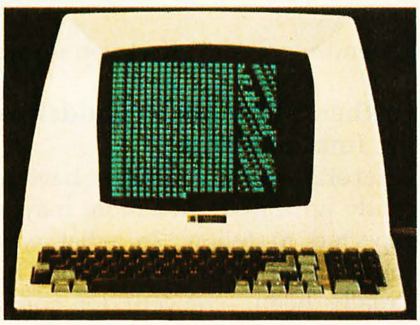

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Conversion in the opposite direction will, in general, be far more difficult, owing to BDS's lack of long ints, doubles, floats, static variables, and initializers.

On the positive side, the BDS C compiler is exceptionally well suited to the CP/M environment. Its library is equipped with the special functions you really need to use the machine: inp( ) and outp( ) for doing port I/O, bdos( ) and bios( ) for communicating with the operating system, and convenience functions like kbhit( ) for testing console status.

More important, the compiler is written in assembly language and optimized to give acceptable performance even on a relatively slow 8080-based microcomputer. (I've never seen another compiler under CP/M-80 that could match its speed of compiling and linking; debugging sessions can be quite lively, which is normally only true with interpreted languages).

Aztec C: There are two compilers I use nearly every day: one runs under Unix version 7 on my company's own 68000-based microcomputer, and the other is the Aztec C compiler that runs on my home Z80 system under CP/M. I routinely move code between the two machines and find that, except for allowable array sizes and execution speed, the behavior in each environment is the same. We have more than upward compatibility here: in the domain of applications programs, we are close to functional equivalence.

Aztec C supports all language features defined in K&R Appendix A except bit fields. A healthy subset of the standard library is supplied, along with source code. Even the mathematical function library, except for the Bessel functions, is provided. That works out well for me, because many of the applications programs I write involve FORTRAN-style number crunching.

Actually, the treatment of the scientific-function library has been done especially well and deserves elaboration. You might suppose that writing routines for sine and cosine is not such a difficult task, but there are many pitfalls for the unwary. The Unix C implementers took this problem seriously and based their code upon the mathematical treatise "Computer Approximations" by Hart et al. The implementers of Aztec C likewise turned to expert authority for guidance, employing the more recent work *Software Manual for the Elementary Functions* by Cody and Waite.

This book contains a series of recipes for writing the standard FORTRAN scientific functions. It also provides a testing program for each of the functions, whereby the final accuracy may be assessed. Out of curiosity, I applied these tests to Microsoft FORTRAN and obtained a surprising result: nearly every function, in both single and double precision forms, shows excessive loss of accuracy over at least some interval of its domain. Aztec C, having passed these tests (in translated form), may be considered reliable for accurate scientific computation.

Aztec C is somewhat weaker than BDS C in its CP/M interface. The function getchar( ), for example, buffers input until a carriage return is detected; it would be more convenient, as in BDS C, to have getchar( ) return its value upon receipt of a single character. The buffering action is also performed under Unix, by the way; there, you get around it by turning on a flag called CBREAK that forces keystroke response. It can be circumvented in Aztec C as well, by redefining getchar( ) or creating a new function, such as

```
#define getkey( )     bdos(1)
```

or else

```
#define getkey( )     bdos(6,0xff)
```

depending on the effect you desire.

Further C Compilers: Guidelines for Implementors

Several new C compilers have recently appeared, and more may be expected to follow. In what ways could these improve on what has already been achieved? Of course they must be complete implementations; if Aztec C can do this, what excuse is there for providing any less?

Portability has to be a main consideration, especially given the emergence of progressively more powerful microprocessors. A formal standard is clearly needed; until it arrives, common sense suggests to me the following simple rule: do not redefine any of the functions appearing in sections 2 and 3 of *The Unix Programmer's Manual*, Volume 1.

The temptation to alter a function definition must occasionally be very great, as in the case of omitting arg0 from execl( ) or making the n in read(fd, buf, n) stand for a number of sectors rather than bytes (both offenses are seen in BDS C). In the latter case, an alternative would be to coin a different name—say, secrd( ) instead of read( )—or, following the example of Walt Bilofsky, the implementer of C/80, retain the meaning of read(fd, buf, n) but restrict n to be a multiple of the sector size. A little discipline is all that's required.

The discussion of the preceding sections reveals the Unix standard library as a rich source of ideas for attractive features. Can system( ) be done in a tasteful way? Can anything useful be done with interrupts (SIGNAL(2)) or communications (PKON(2), PKOPEN(3))?

Bear in mind the role of C as a "high-level assembler." It is intended to allow efficient access to the features of the underlying machine, to provide the capabilities of an assembler with the advantages of an expressive syntax. BDS C has set a fine example with rapid compilation, modest object-code size, and appropriate library enhancements such as inp( ) and outp( ), bios( ) and bdos( ). More can be done.

The ability to open devices as files has already been discussed. This provides a uniform interface to the device, which can be used freely in C programs. The drivers are easier to write and maintain in C than they would be in assembly language. Another area that suggests itself is support for ROM-based applications. Many compilers allow specification of addresses for code and data areas, but that is only part of what's required. There should be convenient

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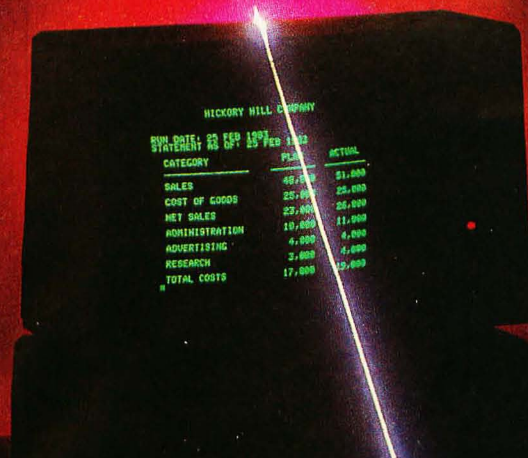

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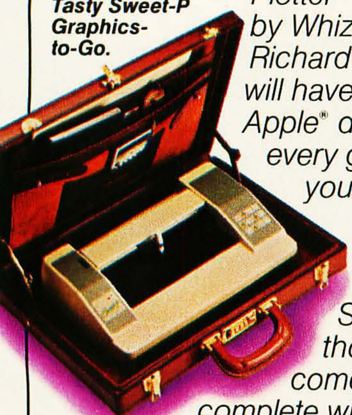

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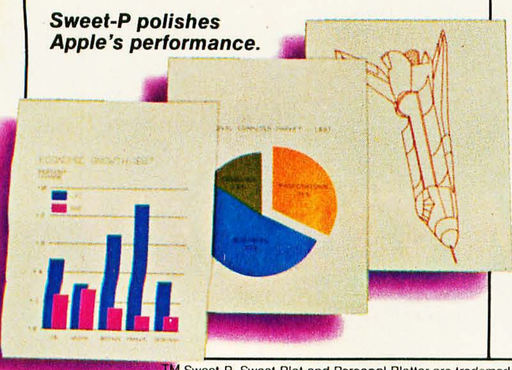

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mechanisms for excluding unneeded parts of the run-time environment, in order to minimize the size of the compiled object.

I/O redirection is obviously worthwhile, but it imposes a definite overhead, and there should be a means of disabling it when it cannot be used. This is always the case for users who run under a CP/M front end like Microshell, which handles the redirection at a higher level.

The need for judgment to discern features from bugs is illustrated by the recent tendency to have the C compiler produce assembler output targeted for Microsoft's M80 assembler, despite the fact that L80 is not a suitable linker for a language allowing identifiers with 8 significant characters of mixed case (with the M80/L80 pair, you are limited to 6 characters, and the case distinction is lost). Aztec C supports M80-compatible output but also provides its own assembler and linker that do the right thing, and this is what I use even though the assembler lacks the macro capability of M80. After all, with C, one doesn't make heavy use of assembly-language routines; when, on occasion, they are required, any working assembler will do.■

Matthew Halfant is a mathematician who, as senior scientist at Bedford Computer Corp. (Tirrell Hill Rd., Bedford, NH 03102), is currently involved with the analytic representation of typographic fonts. He has taught numerous courses in subjects ranging from programming languages to microprocessor-based instrument design.

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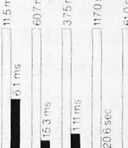

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Annotated C

A Bibliography of the C Language

by Terry A. Ward

You have probably read a great deal about the C language, but just where can you find the books, articles, and reviews that will make this less-than-well-known language part of your repertoire?

While struggling to find reviews of a C compiler that I was interested in purchasing, I thought that other microcomputer users might be having the same problem locating information. This bibliography of 100 items is my attempt to provide some guidance to the literature pertaining to the C programming language.

The material is listed alphabetically by author in both book and periodical sections, and I have also provided an index to the bibliography by subject matter and type of C used (where applicable).

Finally, these are my own opinions and do not reflect the views of BYTE. For me, C is *the* language for micros. To paraphrase a popular book, "Real microcomputers don't use BASIC!"

Books

01 Bell Telephone Laboratories Inc. *Unix Programmer's Manual: Volume 1 and Volume 2* (New York: Holt, Rinehart and Winston, 1983).

These two volumes contain a wealth of information on C and particularly its use with Unix. Volume 1 contains the system calls and subroutines in the standard C libraries and their calling sequence. Volume 2 has a reprint of the C programming language reference manual, an article on lint (the C program checker), and technical tours through the Unix C compiler and the portable C compiler by their respective authors.

02 Feuer, Alan F. *The C Puzzle Book: Puzzles for the C Programming Language* (Englewood Cliffs, NJ: Prentice-Hall, 1982).

In this unique book, Feuer presents fragments and sections of C code and asks, "What does this code do?" Used in conjunction with a working C compiler and Kernighan and Ritchie's book, it provides an excellent way to tackle the nitty-gritty of the language in an enjoyable fashion. Caution: as the author states, "Some of the code is *atrocious*." Style should be learned from Kernighan and Ritchie. Feuer provides interesting puzzles to help learn the language. Heartily recommended.

03 Hancock, Les and Morris Krieger. *The C Primer* (New York: McGraw-Hill, 1982).

This introductory book is paced slowly for beginners, with numerous short examples that depict isolated features of the language. There are more illustrations in this tutorial than in any other C book to help clarify some of C's unusual points.

04 Kernighan, Brian W. and Dennis M. Ritchie. *The C Programming Language* (Englewood Cliffs, NJ: Prentice-Hall, 1978).

This is the definitive work on the C language. Don't read any further until you have this book! Topics such as pointers are obscure, but the book as a whole is excellent.

05 Plum, Thomas. *Learning to Program in C.* (Cardiff, NJ: Plum Hall, 1983).

The newest addition to the all too meager C book literature. Designed to teach programming in C, with emphasis placed upon the programming of portable C applications.

06 Purdum, Jack. *C Programming Guide* (Indianapolis, IN: Que Corporation, 1983).

This is another introductory book on C, oriented toward using C on microcomputers. Most of the programs in the first half of the book will work with inexpensive subsets of the C language, and often the equivalent program in BASIC is shown.

07 Zahn, C. T. *C Notes: A Guide to the C Programming Language*

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(New York: Yourdon Press, 1979).

A reference manual and tutorial for C focusing primarily on the portable features of the language. All major topics are covered and the book is an excellent supplement to Kernighan and Ritchie (see above). Each chapter concludes with a concise syntactic summary chart. Recommended for any C library.

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A technical and critical look at C directed especially at the "infelicities" of the typing of variables in C. Anderson considers the syntax of C to be messy and irregular.

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A brief report on Bell Labs' MAC-32 microprocessor chip. The chip itself is optimized for data manipulation using C.

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A notification and evaluation of a new version of BDS C compiler.

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A description and brief history of the C language, including a review of Kernighan and Ritchie's book.

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Technical description of a tool for the diagnosis of allocation errors in C programs. Consists of a traced replacement for the standard memory allocator, plus a program to analyze traces. This technique is said to make large programs more robust.

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Use of C in an application where assembly language would be used traditionally for speed considerations—medical signal processing.

17 Bolton, Bill. "Some Useful C Time Functions," *Dr. Dobb's Journal* 6(8): 16–21 (August 1981).

Nine time and date functions and a demonstration program for an S-100 hardware clock board are presented.

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Describes how one would organize a database structure in a language such as BCPL. Contains a useful discussion of structural considerations. The author notes that these ideas should be transferable into a C environment.

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A description of a subset of C for small-computer use.

20 Cain, Ron. "A Small-C Compiler for the 8080's," *Dr. Dobb's Journal* #45: 5–46 (May 1980).

This is the original source for the small-c compiler. Complete source code is included. The language is often used by software experimenters with this as the basis for modification. Small-c does not support floating-point, structures or unions, or multiple-dimension arrays.

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Source code and description of the runtime library for the small-c compiler (see Cain, May 1980). The library consists of arithmetic, logical routines as well as the I/O functions for small-c.

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A review of Ed Ream's public-domain editor. A unique feature of the editor is the inclusion of source code (allowing modification and customization by the user). Versions are available from the C Users Group or from Ed Ream. Available in both BDS C and small-c verisons.

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A review of the MINCE editor (from Mark of the Unicorn). MINCE is written in BDS C and includes notes for customization. MINCE features excellent documentation, multiple edit capability, split-screen editing, and other EMACS-type features.

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Update of earlier review of MINCE (see Christensen, April 1982). Highlights MINCE's capability for split-screen multiple-file-editing capability.

25 Christensen, Ward. "The

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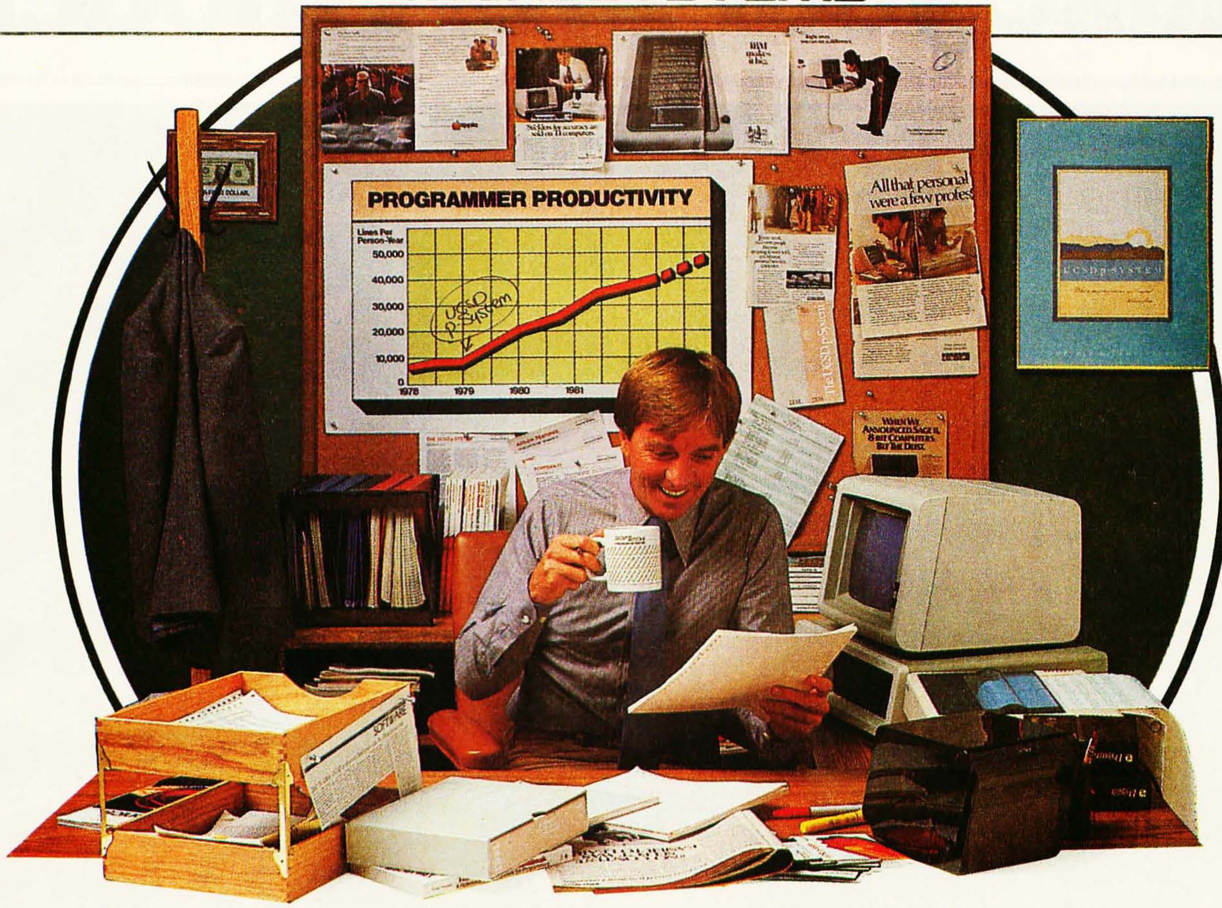

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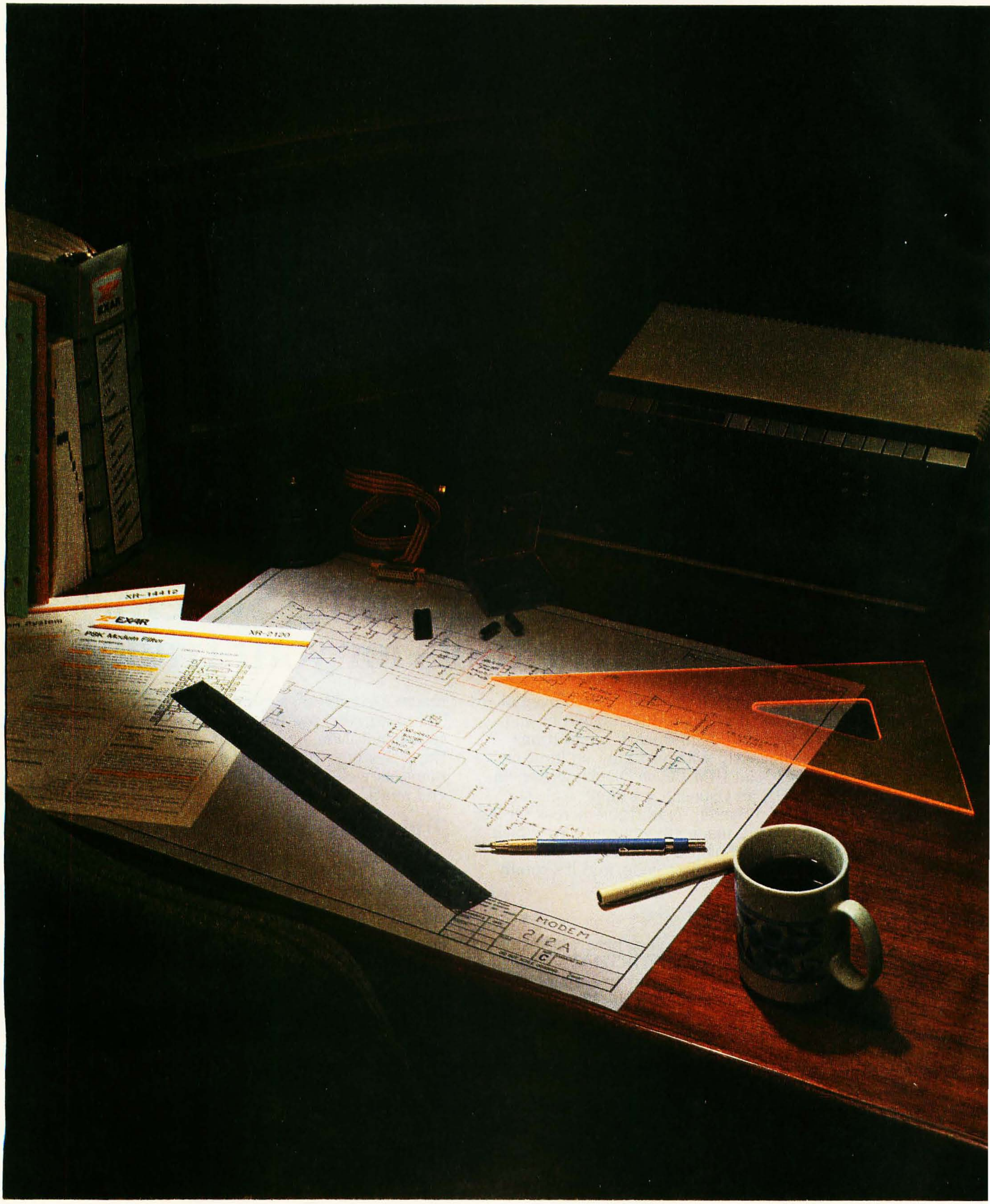

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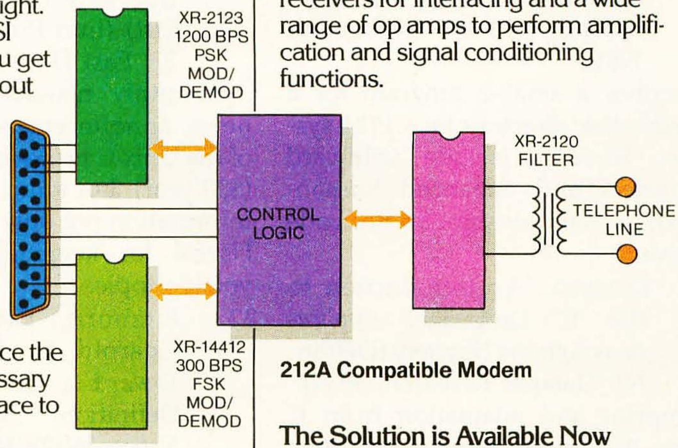

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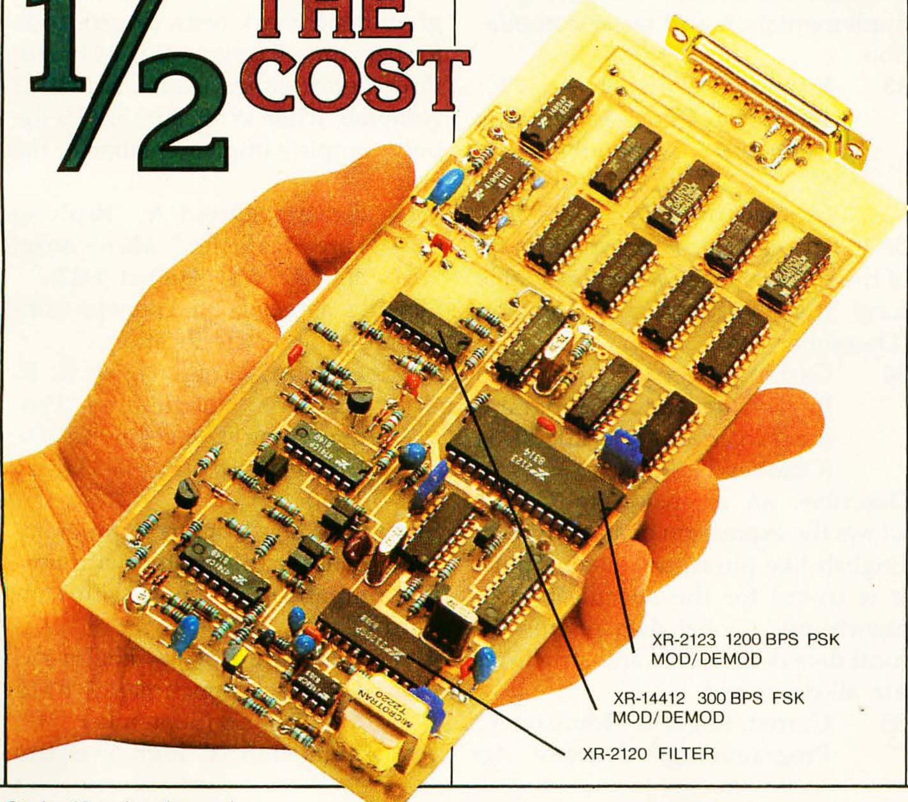

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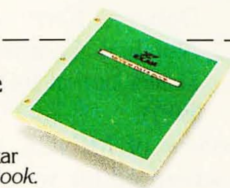

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CP/M Users Group Volume 48: Catalogue and Abstracts," *Lifelines* 1(10): 15–16 (March 1981).

A description and abstract of the BDS C "sampler" disk available from the CP/M Users group. Programs include LIFE, the AWARI game, and a program to "tabify" source code.

26 Cotton, G. "A Master Disk Directory," *Interface Age* 6(11): 104–105, 162–167 (November 1981).

Describes a small-c program for a master disk directory for CP/M systems. Features include wild-card characters and enhanced human-interface characteristics. Source code is given.

27 Datapro. "An Introduction to the 'C' Language," *Applications Software Directory* (Delran, NJ: Datapro Research, 1980).

A reprint and adaptation from *C Notes: A Guide to the C Programming Language* by C. T. Zahn (Yourdon, 1979). Contains a description of C with emphasis on the language's portability. Features examined include syntax, declarations, initializers and statements, machine dependencies.

28 Dobyns, Barry A. "MINCE: Not Just Another Editor," *Dr. Dobb's Journal* 6(4): 48–52 (April 1981).

A review of MINCE, an advanced full-screen editor written in C. The source code for MINCE can be purchased as well.

29 Elliott, Conal. "A Very General Problem-Oriented CAI System," *Behavior Research Methods and Instrumentation* 14(2): 165–169 (April 1982).

A description of a psychology CAI system written in C.

30 Feuer, Alan R. and Narain H. Gehani. "A Comparison of the Programming Languages C and Pascal," *ACM Computing Surveys* 14(1): 73–92 (March 1982).

The authors examine two popular languages—C and Pascal—in terms of their design philosophies, their handling of data types, the programming facilities they provide, and the impact these facilities have on the quality and reliability of programs. Finally, the authors consider the various types of tasks in which these languages can be applied. C is favored for operating systems and utilities programming. Neither language is deemed suitable for business programming. Pascal is favored in scientific programming because of its greater safety.

31 Fiedler, David, ed. *UNIQUE* (formerly *The UNIX* Software List*) (Info Pro Systems, POB 33, East Hanover, NJ 07936).

A monthly newsletter devoted to news, announcements and analysis of the Unix-C marketplace. Expensive ($20/year), but it includes news and information not otherwise available. Useful for keeping track of this volatile topic.

32 Fitzhorn, Patrick A. and Gearold R. Johnson, "C: Toward a Concise Syntactic Definition," *ACM SIGPLAN Notices* 16(12): 14–21 (December 1981).

The paradox of C as a systems implementation language vis-à-vis its "vague (and sometimes incorrect)" grammar description is discussed. The authors present a definition of C that incorporates into the syntax many of the semantics currently describing the language. Advantages to this approach include easier compiler implementation and faster compilation.

33 Fitzhorn, Patrick A. "C: Toward a Concise Syntactic Description: Appendix," *ACM SIGPLAN Notices* 17(8): 89–95 (August 1982).

BNF (Backus-Naur-Form) description of the C language in a more readable form than Fitzhorn and Johnson (December 1981).

34 Garrett, Roger C. "Structured English for the 'C' Programmer," *Interface Age* 6(10): 30–34 (October 1981).

Describes an extension to C that allows the expression of algorithms in English-like phrases. Called C.plus, it is useful for the specification of algorithms. Global data references, local data definitions, and structures are all discussed.

35 Garrett, Roger C. "More on 'C' Programming," *Interface Age* 6(11): 26–28, 158 (November 1981).

A continuation of Garrett's description of C.plus (October 1981) dealing with executable statements, unary operators, and shift and increment/decrement operations. Source code included.

36 Garrett, Roger C. "C.Plus (Conclusion)," *Interface Age* 6(12): 34–38, 142–143 (December 1981).

Garrett's concluding article on extensions to C (C.plus), including decision and looping structures. Source code included.

37 Gewirtz, David A. "An Introduction to the C Programming Language," *Microsystems* 2(6): 20–38 (November/December 1981).

An introductory tutorial on C and evaluation of several popular C compilers (BD Software C, small-c, tiny-C Two, and Whitesmiths C). Differences in implementation are noted.

38 Gewirtz, David A. "An Introduction to the C Programming Language (Part II)," *Microsystems* 3(1): 50-58 (January/February 1982).

A tabular comparison of C compiler implementations (see Gewirtz, November/December 1981) and program benchmark tests. Source code for benchmark programs is included. Price-performance leader is BDS C compiler, while Whitesmiths C is the only complete implementation of the language.

39 Gewirtz, David A. "Reply to Larry Hamelin," *Microsystems* 3(4): 12 (July/August 1982).

Gewirtz agrees with Hamelin concerning pointer clarification.

40 Gibson, T. A. and S. B. Guthery. "Structured Programming, C and tiny-C," *Dr. Dobb's Journal* 5(5): 30–33 (May 1980).

Summary of structured programming concepts illustrated with tiny-C. Comparison of tiny-C with standard C.

41 Gilbreath, Jim. "A High-Level Language Benchmark," BYTE 6(9): 180–198 (September 1981).

An examination of high-level lan-

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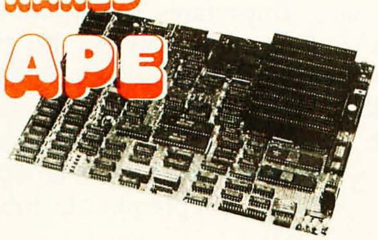

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guage performance using the Sieve of Eratosthenes algorithm on both micro- and mini-based systems. Source code is included for all languages. PL/I-80 rates highest in execution speed, surpassing Whitesmiths C by approximately 10%. Other Cs evaluated include BD Software C and tiny-C. Note that versions of BDS C include a modified Sieve program that would place it just below PL/I-80 in speed.

42 Gilbreath, Jim and Gary Gilbreath. "Eratosthenes Revisited: Once More Through the Sieve," BYTE 8(1): 283–326 (January 1983).

An excellent update and revision of the earlier Gilbreath article (BYTE, September 1981) on the Eratosthenes Sieve program as a benchmark for several languages. After presenting normal timing data, the authors also show the effect optimizing can have on benchmark speed. A second benchmark is presented that exercises the computer's operating system—language interface. The authors make two very interesting observations concerning C: first, that "the degree of compatibility among the C compilers is remarkable" (as they note, no C standard exists); second, that "programming in C is fun, like driving a small car." All in all, this is an excellent article on this specific benchmark and the whole benchmark approach. Source code for benchmarks is included.

43 Hamelin, Larry. "Intro to the C Programming Language," *Microsystems* 3(4): 12 (July/August 1982).

Note to the editor concerning ambiguity in the description of pointers in the Gewirtz series (see David Gewirtz's articles).

44 Hancock, Les. "Growing, Pruning and Climbing Binary Trees with tiny-C," *Dr. Dobb's Journal* 4(5): 37–41, 54 (May 1979).

The use of tiny-C in implementing a complex data structure (here, binary trees) is shown. Extensive use and discussion of pointers. Source code is included.

45 Hancock, L. "Implementing a Tiny Interpreter with a CP/M-flavored C," *Dr. Dobb's Journal* 5(1): 20–28 (January 1980).

Presents the implementation of a simple interpretive language on CP/M using the BDS C compiler. Useful discussion of the parts of an interpreter. Source code is included.

46 Hendrix, J. E. "Small-C Expression Analyzer," *Dr. Dobb's Journal* 6(12): 40–43 (December 1981).

Patches for three problems with the address arithmetic in the small-c expression analyzer are given.

47 Hendrix, J. E. "Small-C Compiler, v. 2," *Dr. Dobb's Journal* 74: 16–52 (December 1982).

Improved version of the classic small-c compiler (see Ron Cain's articles for details of the original). Improvements include code optimization, data initialization, compiler directives, and numerous others. (Hendrix lists 18 new features.) An excellent starting point for any C software hacker. Full source code is included. This series is destined to the same fame accorded the original small-c.

48 Hendrix, J. E. "Small-C Compiler, v.2 Continued," *Dr. Dobb's Journal* 75: 48–64 (January 1983).

Continuation of the source code listing for a new, improved small-c. Details of the compiler can be found in Hendrix's December 1982 article.

49 Hogan, W. L. "An Evaluation of a Raster Scan Display for Use in an Aircraft Information Handling System" (Master's thesis, Naval Postgraduate School, Monterey, CA, 1977).

Information system written in C.

50 Howard, J. E. "An Implementation of a Codasyl Based Data Base Management System Under the UNIX Operating System" (Master's thesis, Naval Postgraduate School, Monterey, CA, 1978).

Data handling features of the system are written in C.

51 Hughes, Phil. "BASIC, Pascal or Tiny-C? A Simple Benchmarking Comparison," BYTE 6(10): 372–375 (October 1981).

The author uses a simple "card-shuffling" benchmark program to test three popular microcomputer languages. Tiny-c fares poorly, but see BYTE, September 1981 (pp. 180–198) for benchmarks of other compilers (BDS, Whitesmiths, tiny-C II).

52 Jackson, T. R. "Letter to the Editor," *Microsystems* 3(5): 22–23 (September/October, 1982).

This letter notes several problems in David Gewirtz's article series on C compilers.

53 Johannson, Jan-Henrik. "Argc and Argv for Small-C," *Dr. Dobb's Journal* 74: 62–64 (December 1982).

An enhancement to the Code Works version of small-c to implement command-line arguments and I/O redirection.

54 Johnson, S. C. "A Portable Compiler: Theory and Practice," in *Proceedings 5th ACM Conference on Principles of Programming Languages* (1978).

A technical discussion of the design considerations in the first C compiler.

55 Johnson, S. C. and D. M Ritchie. "Portability of C Programs and the UNIX System," *Bell System Technical Journal* 57 (6; pt. 2): 2021–2048 (July/August 1978).

Discusses the theory behind the C features that enhance program portability. Case study presented with transfer of programs from DEC to Interdata systems. (See Gilbreath and Gilbreath, January 1983, for examples of portability on microprocessor C systems.)

56 Joyce, J. "Review of *The C Puzzle Book*," *ACM Computing Reviews* (June 1982): 286.

Contains a brief review of *The C Puzzle Book* (see Alan Feuer, 1982) suggesting that it can be useful in exploring interdialect differences in C implementations.

57 Kern, Christopher. "A User's Look at Tiny-C," BYTE 4(12): 196–206 (December 1979).

Includes extensive favorable analysis and review of the tiny-C interpreter. Highlights the program preparation system (written in tiny-C itself), as well as the differences between C and tiny-C. Commends tiny-C for superior documentation. Includes tiny-C program sample with explana-

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tion.
58 Kern, Christopher. "Printf for the C Function Library," BYTE 6(5): 430–434 (May 1981).
An enhancement to early versions of BDS C that allows the very useful printf to be used in output processing. Allows printing of numerical data in octal as well as variable precision. Souce code and sample program using the function are included.
59 Kern, Christopher. "The BDS C Compiler," BYTE 6(6): 356–362 (June 1981).
A product review of the BDS C Compiler that notes the power and conciseness of C vis-à-vis Pascal. Includes a comparison of C and Pascal aimed at those "not ideologically committed to the proposition that Pascal is the most congenial programming language." The only complaints are with lack of floating-point (available in library functions) and redirection of I/O (also included in later versions as library functions).
60 Kern, Christopher. "MINCE: A Text Editor," BYTE 6(9): 150–160 (September 1981).
A product review of the MINCE (MINCE Is Not Complete EMACS) editor, which is written in BDS C. Useful features noted include multifile capabilities as well as the ability to modify the editor to one's own needs. MINCE is a good example of the power of BDS C. One major complaint is that MINCE is slow. Kern commends MINCE for excellent documentation.
61 Kern, Christopher. "Microshell and Unica: Unix-style Enhancements for CP/M," BYTE 7(12): 206–219 (December 1982).
A product review of two Unix-style operating shells for CP/M. Both Microshell and Unica are considered to be useful enhancements to CP/M by increasing the system's flexibility and user friendliness. Note is also made that MARC is a complete operating system, not simply a CP/M enhancement.
62 Kern, Christopher O. "The Scribble Text Processor," BYTE 8(2): 302–309 (February 1983).
A product review of the Scribble text processor. The companion processor to the MINCE text editor, SCRIBBLE may be described as a high-level language for text manipulation. As with other Mark of the Unicorn products, documentation is superb (100-page user manual and a comprehensive program logic manual). Kern notes that SCRIBBLE is best when processing large, complex documents.
63 King, B. "The Flexibility of C," *CP/M Review* 1(2): 22–23, 75 (January/February 1983).
Brief and accurate discussion of C's feaures by an author "who refuses to work at a company that doesn't use C."
64 Krieger, M. S. and P. J. Plauger. "C Language's Grip on Hardware Makes Sense for Small Computers," *Electronics* (May 8, 1980).
The authors (both of Whitesmiths and one of *Software Tools* fame) describe C and its use in small-computer environments where portability between processors is important. Useful presentation of pointer arithmetic is included, as well as a description of Whitesmiths A-Natural code (a narrative type of assembler code). As the authors conclude, "It is ironic that the ability to write very machine-dependent code with C has encouraged its portability. By filling the gap between assembly language and traditional high-level languages, C has succeeded in wooing numerous converts from both camps."
65 Libes, Don. "Reply to T. R. Jackson," *Microsystems* 3(5): 23–26 (September/October 1982).
A reply to Jackson's letter noting typographical and other errors in David Gewirtz's series of articles on C compilers (see T. R. Jackson, September/October 1982).
66 Madden, J. Gregory. "C: A Language for Microprocessors?" BYTE 2(10): 130–138 (October 1977).
An early (dark ages of 1977) article extolling the virtues of C with a tutorial presentation of its primary features. Notes I/O capabilities and control structures. Written before any microcomputer Cs existed, the article concludes with a hopeful "wait and C." Today, one need simply "look and C."
67 Mark of the Unicorn, *MINCE Text Editor Documentation* (Mark of the Unicorn, 1981).
While it might seem unusual to include a user manual for a specific text editor in a bibliography on the C language, my reasons are many. First, MINCE is written in C, specifically BDS C, and includes details on how to customize the editor using the C language. Second, this manual is the finest technical manual I have ever seen. It even includes a section (of some 50 pages) that discusses the consideration involved in implementing any text editor. Mark of the Unicorn is to be commended for using C and providing means for software modification. MINCE is highly recommended as an excellent example of a complete system. (See Christopher Kern's articles for reviews of the entire Mark of the Unicorn's text system—MINCE/SCRIBBLE.)
68 Mateti, Prabhaker. "Pascal Versus C: A Subjective Comparison," in *Proceedings of the Symposium on Language Design and Programming Methodology* (Sydney, September 10–11, 1979); pp. 37–69.
Discusses Pascal and C, noting that both possess comparable data and control structures. The program structure of C is considered superior, although the power and ambiguity of C also pose dangers to the programmer. C's powerful features are counterbalanced by its tendency for obscure code. As Mateti notes, "Excellent programs can be written in either language. . . . I am concerned that it is all too easy to write incomprehensible programs in C."
69 McSkimin, J. R. "REDAS—A Relational Data Access System for Real-Time Applications," in *Proceedings of COMPSAC 1978* (Computer Software and Applications Conference, 1978).
Interpretive database retrieval system written in C.
70 Meissner, Michael. "Letter to the Editor," *ACM SIGPLAN Notices* 17(8): 84–88 (August 1982).
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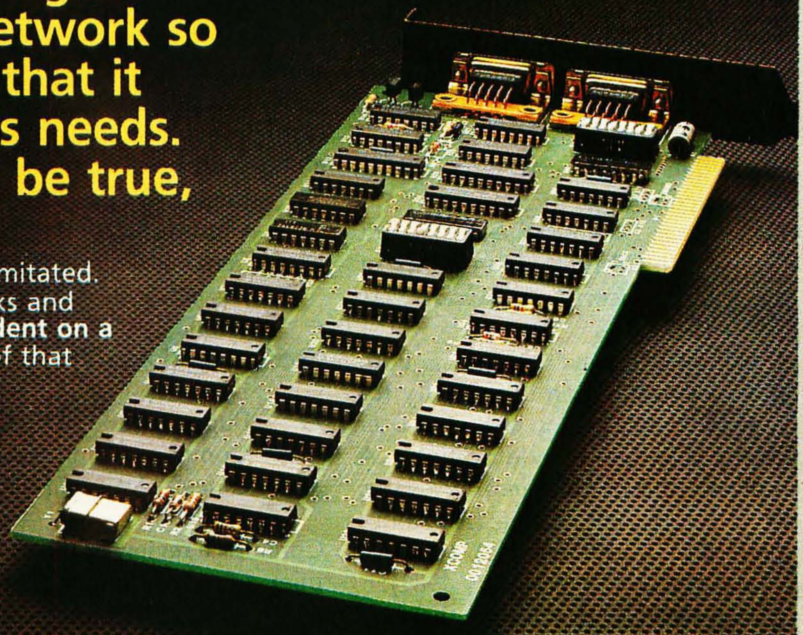

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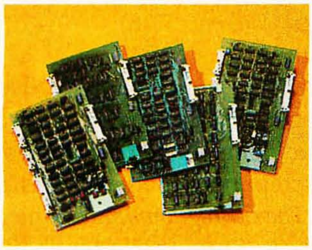

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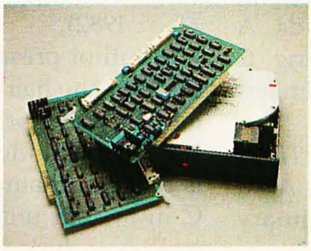

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on the Fitzhorn and Johnson article (December 1981). Clarification of the comma (,) operator in C, as well as such features of C as sizeof, arithmetic if, and types are included. Should be read in conjunction with Fitzhorn and Johnson.

71 Mohler, Lorin S. "A Disk Alignment Routine," *Microsystems* 2(6): 70 (November/December 1981).

A disk-alignment routine for Tarbell single-density drives written in BDS C. Source code is included.

72 Ness, David and A. Krigman. "MINCE Editor from Mark of the Unicorn," *Infoworld* (May 11, 1981).

A favorable review of MINCE with special emphasis on its capacity for large file manipulation tasks and user extensibility and modification. A typically thorough *Infoworld* review.

73 Norris, Bill. "C-Bits (All About BDS C version 1.45)," *Lifelines* 2(9): 37–38 (February 1982).

A note briefly describing the bug fixes, new features, the new linker, and the file sieve.doc (benchmarking program).

74 *Pipes and Filters* (publication of Uni-Ops, POB 582, Walnut Creek, CA 94596-1182).

A newsletter/journal for Unix, C, and Software Tools news and trends. A useful guide to the expanding C field. (See David Fiedler for a similarly useful newsletter.)

75 Plauger, P. J. "Review of *The C Programming Language*," *ACM Computing Reviews* (January 1979): 2–4.

Plauger considers C to be "one of the important contributions of the decade to the practice of computer programming" and notes that Kernighan and Ritchie's book is the definitive treatise on the subject. Although the reviewer is concerned over consistency of presentation, this is, all in all, a very favorable recommendation of the "C bible."

76 Pournelle, Jerry. "User's Column . . . MINCE Is Not Complete EMACS," BYTE 7(7): 294, 298, 300 (July 1982).

Pournelle reviews MINCE unfavorably, although he admits his own prejudice. He notes the good features of MINCE, but specifically also dislikes MINCE's habit of telling the user "things I don't want to know." Concludes by saying that others like MINCE.

77 Pournelle, Jerry. "User's Column . . . There's a New C A' comin'," BYTE 7(12): 230, 235, 236 (December 1982).

Includes a brief mention of the major C compilers available. The software developers' addresses are given along with brief evaluations.

78 Pugh, T. J. "MCALL-C: A Communications Protocol for Personal Comuters," *Dr. Dobb's Journal* 5(2): 16–20 (June/July 1980).

Communications software written in C.

79 Pugh, Tim. "BDS C, A Full Compiler from Lifeboat Associates," *Infoworld* (March 31, 1980).

Contains a review of the BDS C compiler with comparisons to Whitesmiths full C compiler. Concludes that BDS C could use improved error-handling capabilities but that in terms of price-performance ratio, BDS C is an excellent product.

80 Reed, Adam. "An Underline Filter for Matrix Printers," BYTE 7(3): 300–306 (March 1982).

The author presents a program in C that sets the half-line spacing option for DECwriter printers, thus allowing fast, legible underlining of text. This is a useful example of the power of C in system utility writing. Source code is included.

81 Reid, Larry and Andrew P. McKinlay. "Whitesmiths C Compiler," BYTE 8(1): 330–344 (January 1983).

An excellent discussion of the "cadillac" of C compilers, Whitesmiths C, which features full Unix version 7 compatibility. The inclusion of I/O redirection and command-line arguments makes the user interface for Whitesmiths C programs much more friendly. With Unix 7 compatibility, Whitesmiths C programs are extremely portable (however, note the Gilbreaths' comments on the ease of portability in all Cs). Whitesmiths' documentation is excellent and the system is heartily recommended by the authors in spite of its high cost (about $550).

82 Reitz, Randy. "Small-VOS and Small-Tools," *Microsystems* 4(1): 66–69 (January 1983).

This article describes the use of small-c to implement 14 of the text-processing programs inspired by the book *Software Tools* by Kernighan and Plauger. A short section is also devoted to a discussion of small-c itself.

83 Ritchie, D. M., S. C. Johnson, M. E. Lesk, and B. W. Kernighan. "The C Programming Language," *Dr. Dobb's Journal* 5(5): 20–29 (May 1980).

The authors present an overview of the semantics and syntax of C. The strengths and weaknesses of the language are discussed, with the authors concluding that C is likely to remain a high-level assembly-language replacement into the far future. Useful discussions of the C preprocessor, pointers, and derived types are included. A highly recommended article (reprinted from *Bell Systems Technical Journal*; see below).

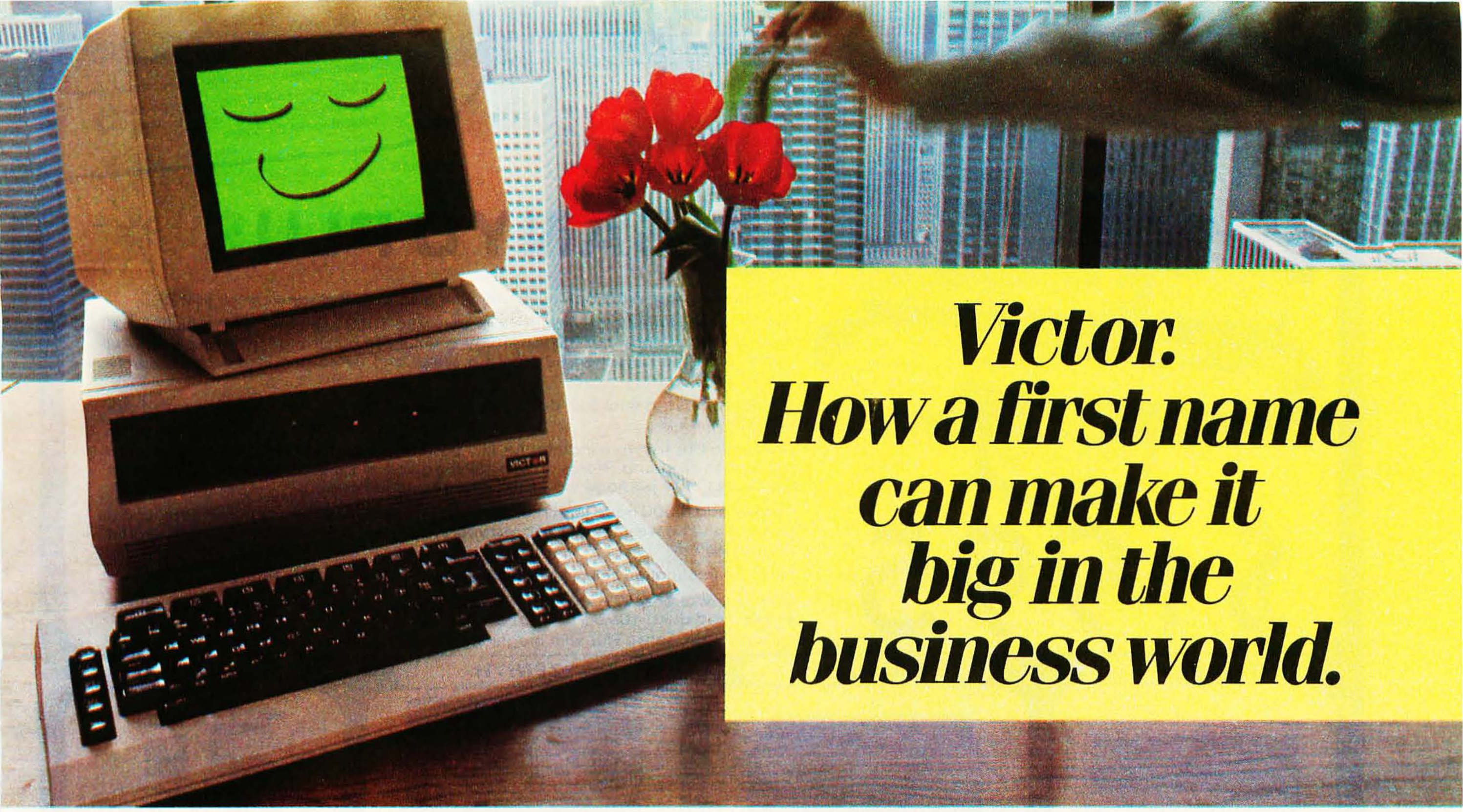
84 Ritchie, D. M, S. C. Johnson, M. E. Lesk, and B. W. Kernighan. "UNIX Time-Sharing System: The C Programming Language," *Bell Systems Technical Journal* 57(6): 1991–2019 (July/August 1978).

An article from the source of C itself describing the language, its power, and its problems. Note that there are some discrepancies between this article and *The C Programming Language*, Appendix A. Only the latter should be considered the definitive description of the language. This article has been reprinted in *Dr. Dobb's Journal* "C Issue" (May 1980) and is highly recommended.

85 Robertson, M. D. "An Extended BASIC Compiler with Graphics Interface for the PDP-11/50 Computer" (Master's thesis, Naval Postgraduate College, Monterey, CA, 1977).

BASIC compiler written in C to run under the Unix system.

86 Rovegno, H. D. "Using C Language for Microprocessors," in *Electro/77 Conference Record* (1977).



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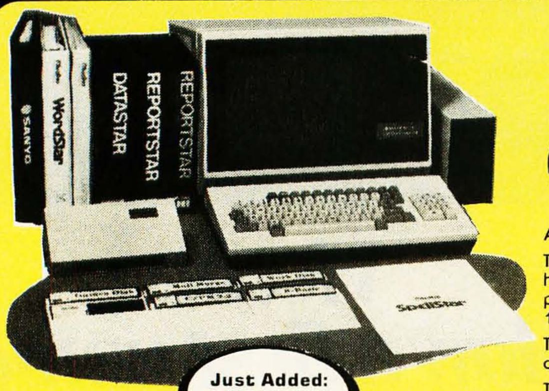

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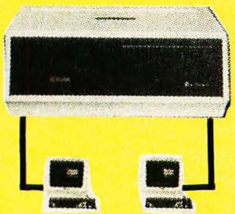

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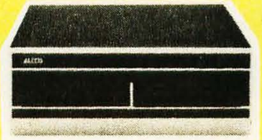

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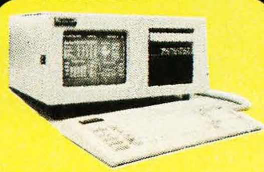

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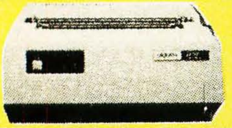

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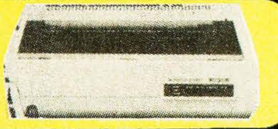

A description of C with particular emphasis upon good documentation practice.
87 Rovegno, H. D. "A Support Environment for MAC-8 Systems," *Bell Systems Technical Journal* 57(6; pt. 2): 2251–2264 (July/August 1978).
A description of the support packages available for the Bell System's MAC 8 microprocessor system that is optimized for C.
88 Runyon, John. "Review of *C Notes: A Guide to the C Programming Language," DEC Professional* (November 1982): 22–26.
Runyon considers the book *C Notes* by C. T. Zahn to be an excellent reference manual to use as a supplement to Kernighan and Ritchie. He estimates C to be a more "universal" language than either COBOL or FORTRAN.
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A case study of the use of C in a traditional assembly-language application, a communications switching network.
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A very technical study of C using denotational semantics.
91 Skjellum, A. "Argnum—A 'C' Command Line Processor," *Dr. Dobb's Journal* 70: 10–31 (August 1982).
An enhancement package to BDS C to simplify the process of command line argument interpretation. Complete source code is included and it appears to be easily modifiable and portable.
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Skjellum argues that C can be a replacement language for the traditional assembly-language systems programming tasks. Features are presented (e.g., pointers, program structure, local variables) that make C a powerful language for systems work.
93 Springer, Allen. "A Comparison of Language C and Pascal," Technical Report G320-2128 (IBM Cambridge Scientific Center; Cambridge, MA, 1979).
Another general comparison of C and Pascal.
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A subroutine library in C for use under Unix in graphics processing.
95 Stroustrup, Bjarne. "Classes: An Abstract Data Type Facility for the C Language," *ACM SIGPLAN Notices* 7(1): 42–51 (January 1982).
A technical article that describes the construction of a new data type facility in C, the *class*. This construct can be used to restrict access to a data structure or to a specific set of functions associated with it. *Class* is defined in the standard C language and source listings are provided. Difficult reading, but an interesting example of C's extensibility.
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A system utility written in Whitesmiths C that provides source listing outputs for compiler error listings and which uses RT-11 system-specific date routine for heading. Source listing included and should be adaptable (without DATE) to other processors and Cs.
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Description of BDS C compiler.
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An occasional publication directed to all users of the C language in any form. Emphases include notes of C Users Group disks of public-domain C programs, as well as technical information of interest to users of any version of C. Essential for all C users.
99 Whitesmiths *C Programmers' Manual* (Whitesmiths Ltd., 97 Lowell Rd., Concord, MA 01742).
A four-part manual describing the Whitesmiths C implementation with sections on run-time library portability issues.
100 Whitesmiths *The C Letter* (Whitesmiths; three issues per year).
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Terry A. Ward is a programmer/analyst for Academic Computing Services, University of Northern Iowa, Cedar Falls, IA 50614.

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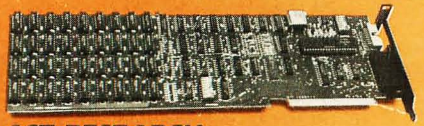

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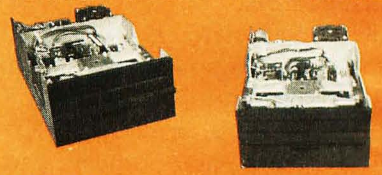

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Chisel Your Code with a Profiler

This software tool can help you speed up compiled programs

by Dennis Leas and Paul Wintz

The time and effort required to construct a software program for a microcomputer application depend on the tools available. Without software tools it may not be feasible; with an assembler it may take months; with a compiler an application program can be written in only weeks.

A compiler is a tool that reduces the amount of toil required to design, code, debug, and document a program by about a factor of 10. Unfortunately, this 10 to 1 advantage is offset by at least a 2 to 1 size disadvantage. That is, a compiled program's object code is typically at least two times longer than it would be if the program had originally been written in assembly language by a competent programmer.

The amount of code generated is not usually a problem. Each additional 2000 bytes of code above a system's limit require another EPROM (erasable programmable read-only memory) or ROM chip. Unless you plan to set up 1000 or more identical systems running the program, the extra ROM per system is preferable to the time and expense it would take to write the program in assembly language.

On the other hand, some applications are significantly hampered by the time required by the processor to execute compiled code. If the compiler produces twice as much code, the processor will take twice as long to execute the code. If the additional execution time cannot be tolerated, you must either rewrite the program in assembly language or find some way to make the compiler-generated code execute faster.

A profiler isolates a section of the code so that you can optimize it for fastest execution time.

Editor's Note: *The profiler program discussed here, written in a combination of C and assembly language, was developed on a Wintek Sprint 68 microcomputer, a 6800-based software development system. However, this programming technique is sufficiently flexible for you to implement it on most microcomputers. . .* **S. J. W.**

Enter the Profiler

A profiler is a computer program that allows you to modify the compiled program in order to reduce the execution time to nearly what it would be if the program had been written in assembly language, but at only a fraction of the effort and cost.

Why It Works

If you analyze a microprocessor system that is executing compiled code, you almost always find that the processor spends 90 percent of its time executing 10 percent of the code. In other words, the processor spends most of its time executing a particular subroutine or a small section of the code. The idea is to locate this particular section and then modify it to execute faster. Clearly, finding this section and rewriting it in assembly language is preferable to rewriting the entire program in assembly language.

A profiler isolates a section of the code so that you can optimize it for faster execution time. If the execution speed of this section of the code can be increased by a factor of 2, the execution speed of the total program will be increased by nearly the same factor. The final product is a compiled program that remains twice as large as the equivalent assembly code

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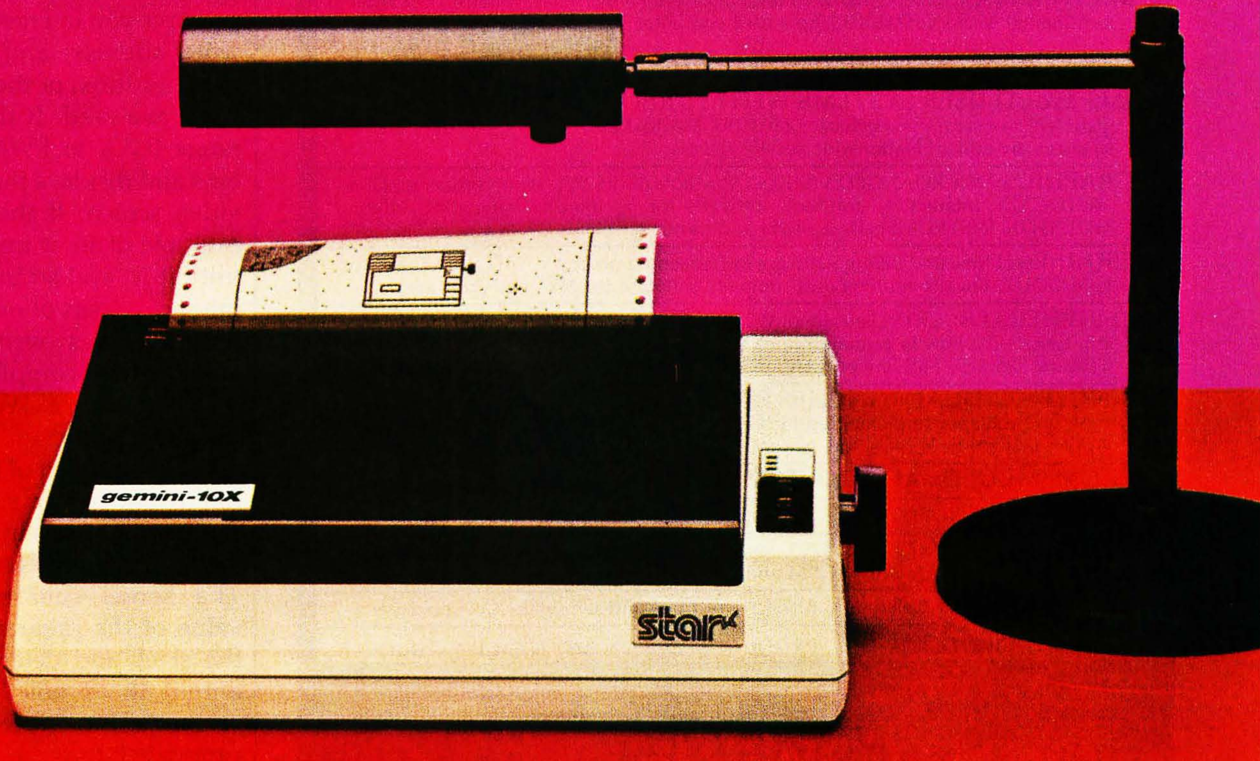

but executes at about the same speed as if it had been written entirely in assembly language.

The profiler monitors an application program while it executes and then computes and displays a histogram of the length of time the application program spends executing different subsections of its code.

Our version of a profiler is an interactive program that first asks you to specify the section of code to be profiled by stating a start address and a stop address. The section of code to be analyzed could, of course, be the entire program. The profiler then divides this section of code into 16 subsections called "bins." As the applications program executes, the microprocessor interrupts every 1/6 second and the profiler examines the program counter. If the value in the program counter (the instruction address) falls within the section to be profiled, the profiler scores a hit and records which of the 16 bins contains the hit. This process continues until the program finishes or one of the bins fills with a maximum of 255 hits. At this point you can elect to display a histogram of the bin hits in a bar graph on a standard video-display terminal or line printer.

Details of the Profiler

Our profiler's parameters were chosen mainly to facilitate writing the profiler program. The number of bins—16—is convenient for arithmetic operations and as a number of bars to display in horizontal bar graph format on a conventional video display terminal. Six interrupts per second appear to be sufficient and posed no design problems for our profiler because 8-inch floppy-disk drives spin the disk at a rate of 6 revolutions per second and generate an index pulse once per revolution. (On the Wintek Sprint 68 microcomputer the only additional hardware required for the profiler is a jumper on the floppy controller module to feed the index signal to an unused PIA control line to generate the interrupts.)

Our profiler consists of an interactive part and a kernel. The interactive part handles the user interface. It prompts you to enter the FWA (first-word address) and the LWA (last-word address) of the section of code to be analyzed. It then divides this range (LWA to FWA) into 16 equal bins and displays the bin size on the video screen. If the range is not a multiple of 16, it increases the LWA until it is, and so informs you. The interactive part of our version of the program was written in the C language and compiled into 6800 object code on a Wintek Sprint 68 microcomputer.

The kernel part of the profiler is an interrupt-handler subroutine. As a program executes in the normal way an interrupt occurs every 1/6 second. The kernel subroutine reads the value of the program counter from the stack and determines if it falls within the profile range. If so, it scores a hit, increments the appropriate bin counter, and ends with a return from interrupt. When a bin is full (255 hits) interrupts are disabled and the program executes to completion. Our version of the kernel

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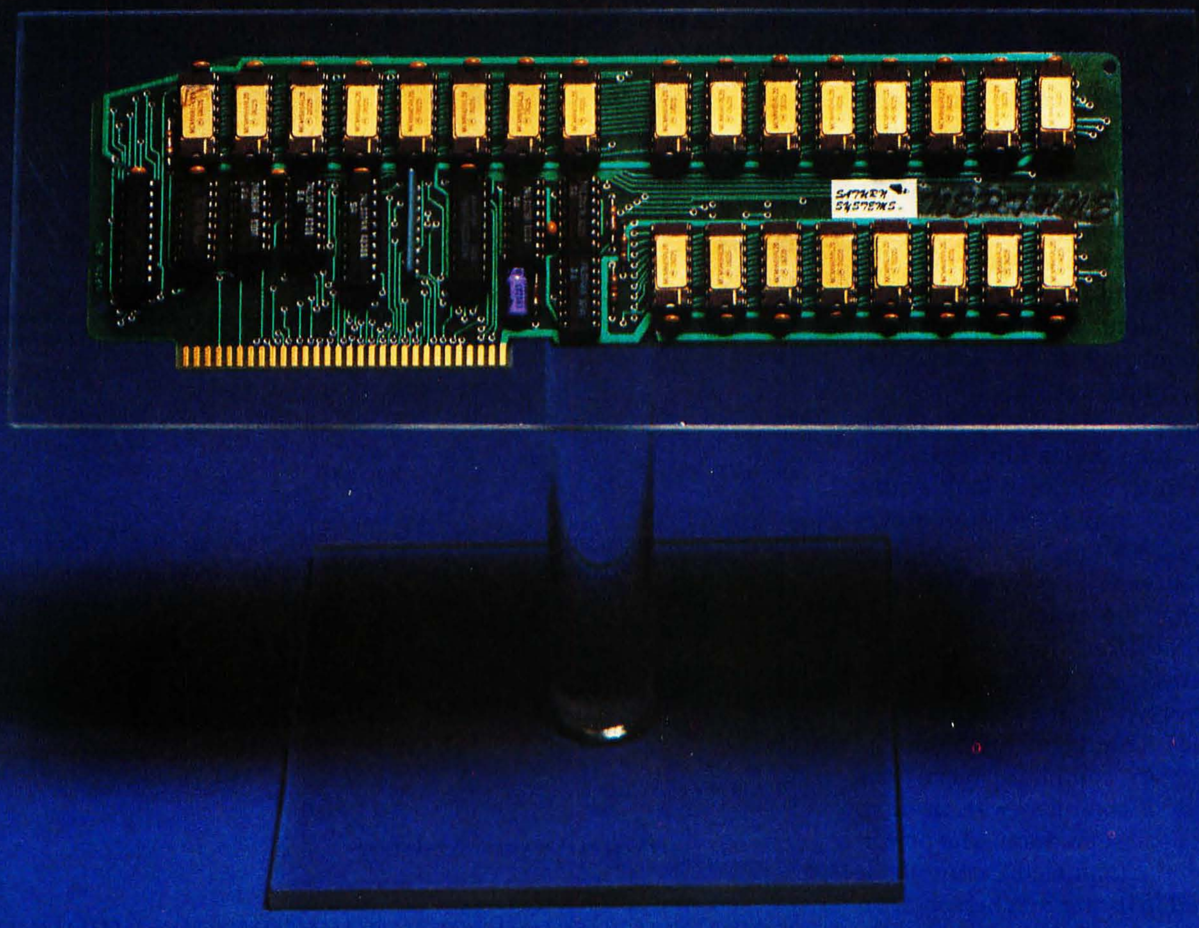

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At this point you can direct the interactive part to display a histogram on the video screen or line printer. The histogram is displayed as a horizontal bar graph with the length of each of the 16 bars proportional to the number of hits in the corresponding bin. The profiler scales the bars so that the longest bar is equal to 80 (the number of characters per line on typical video-display terminals).

A Case History

Wintek started the development of a resident 6800 C compiler in 1979 by writing it in C, using the C compiler to compile itself, and writing a 6800 code generator. When first brought up on Wintek's Sprint 68 microcomputer, the C compiler ran too slowly; a test program required 10 minutes and 45 seconds to compile.

We ran the profiler on the compiler as it compiled the test program and obtained the histogram presented in listing 1. Note that the processor spent about half of the 10 minutes and 45 seconds executing the code in the range of 7898 to 8098 (hexadecimal memory addresses). We decided to take a closer look at this section by running the profile over the range 7898 to 8098. This higher-resolution view, shown in listing 2, shows that the code between 7C18 and 7D18 offered the best prospect for improvement. Consequently, we carefully rewrote these routines in assembly language to obtain a modified C compiler. Next, the modified C compiler was used to compile the test program. The performance of the improved C compiler is presented in listing 3. When comparing listings 1 and 3, keep in mind that our profiler scales the histogram so that the largest bin count is 80. The results show that we removed the bottleneck and reduced the execution time from 10 minutes and 45 seconds to 6 minutes and 35 seconds.

Listing 1: *Output of our profiler from the examination of the C compiler as it compiled a test program. The histogram shows the relative number of times that the processor was interrupted while executing code within each of the 16 different memory locations or bins. The listing shows that code within the memory area of 7898 hexadecimal took the most processing time to execute.*

```
01 SYO:PROFILE HISTOGRAM
645 hits recorded
4898 *
5098 *
5898 ***
6098 *******
6898 ****
7098 ***********************
7898 ***********************************************************************
8098 *******************
8898 *****
9098 ****
9898 *
A098 **
A896 *****************************
B098 *
B898 *************
C098 ****
```

Listing 2: *Modified examination of the C compiler as it compiled the test program. By redefining the area of memory recorded by the profiler, we gained a more detailed histogram showing that the code within memory area 7C18 through 7C98 hexadecimal took most of the processing time.*

```
01 SYO:PROFILE HISTOGRAM
519 hits recorded
7898 *
7918 *
7998 *
7A18 ****
7A98 *
7B18 *
7B98 *
7C18 ***********************************************************************
7C98 ****************************************************************
7D18 **
7D98 *
7E18 *
7E98 *
7F18 *
7F98 *
8018 ****
```

Listing 3: *Histogram for the revised C compiler. With the processing bottleneck removed, the listing shows a relatively even amount of time required for all sections of the compiler code. The execution time improved from 10 minutes 45 seconds for the original version to 6 minutes 35 seconds for the revised version.*

```
01 SYO:PROFILE HISTOGRAM
1001 hits recorded
4898 *
4C98 *
5098 *
5498 **
5898 ******
5C98 ****
6098 *
6498 *************************************
6898 ***********************
6C98 **
7098 ***************************
7498 ***********************************************************************
7898 ********
7C98 ***************************
8098 ****************************************************
8498 **************************
```

Summary

The use of a profiler can greatly speed the development of compiled programs. Because 90 percent of program execution time is required by 10 percent of the code, modifying the slow 10 percent of the code will be a more efficient use of your time than writing the entire program in assembly language. By developing your own profiler program you can significantly reduce the toil and time required for program development.■

Dennis Leas is a software engineer for Wintek Corporation (1801 South St., Lafayette, IN 47904). He holds a degree in electrical engineering from Purdue University.

At the time the article was written, Paul Wintz was president of Wintek Corporation. He has since retired from the company and is living in New Zealand.

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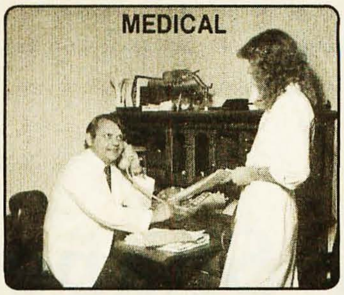

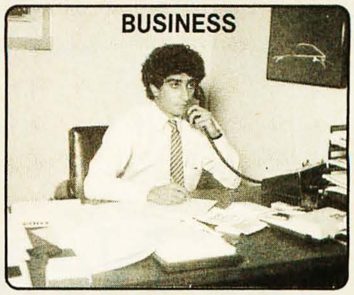

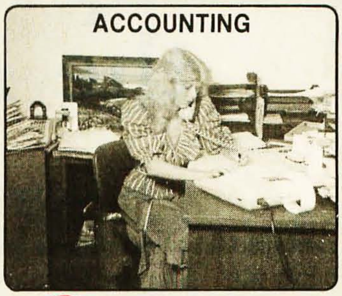

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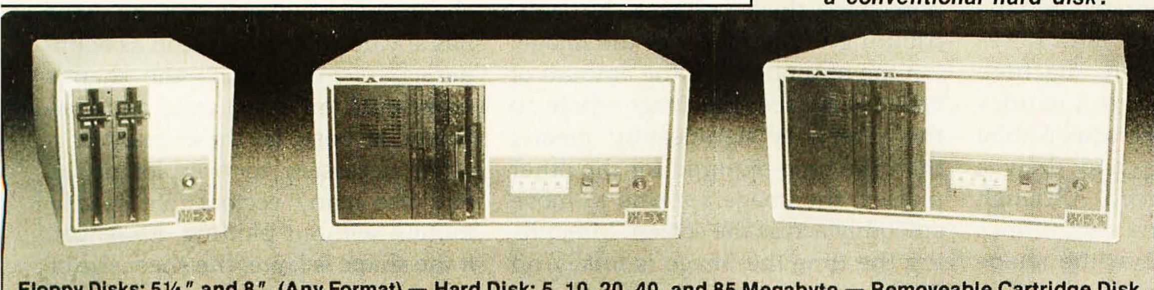

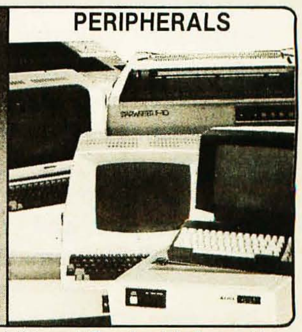

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A New Shape Subroutine for the Apple

by Richard T. Simoni Jr.

Athletes pole-vault, race cars spin, and fighter planes fire at enemy aircraft. Is this the real world? No, I'm talking about fast, smooth animation on the Apple II high-resolution graphics screen. In the past year, dozens of new Apple II programs have achieved such awesome animation capabilities that several years ago most Apple programmers would scarcely have believed them possible. After trying unsuccessfully to match the quality of the commercially produced animation in my own assembly-language programs, I realized that the problem stemmed from the standard Apple shape subroutine that I was using to display the shapes I wanted to animate.

Standard Hi-Res Package

The hi-res (high-resolution) graphics package I was using is the standard package supplied by Apple Computer. It once was supplied with all Apple II computers sold, and it can now be found on the volume 3 disk of the Apple Software Bank Contributed Programs, available from Apple dealers. Indeed, this package was eventually incorporated into the Applesoft language to add hi-res commands. Written in machine language, the package includes *subroutines* to clear the screen, plot a *point*, *draw* a line, and draw a shape on the hi-res screen. Although the clear, plot, and line subroutines work well in animation, the shape subroutine is much too slow to allow shapes to move across the screen quickly, smoothly, and without flickering.

The speed of the shape subroutine is the most important factor in animation for two main reasons. First, the speed with which the subroutine can plot the shape, erase it, and plot it again in its next position limits how fast any shape can move across the screen. Second, in a typical animation scheme, a shape moves from one position to the next in four phases, which correspond to the time required to plot the shape, the time the shape remains on the screen, the time required to erase the shape, and the time that the shape is not on the screen at all. These four phases repeat each time a shape moves to a new position. The time spent during each phase of the process determines how fast the shape moves and how smooth and flicker-free the animation looks. To maximize the smoothness, the time used in plotting the shape, erasing the shape, and leaving the shape off the screen must be minimized, for the human eye perceives these phases as contributing to the flicker of the image. On the other hand, if the amount of time the eye sees the image whole on the screen is significantly greater than the time required for the other phases, the image appears to move smoothly across the screen. Minimizing the time the image is totally off the screen is not difficult, for all calculations for the next plot can be done while the image is on the screen; when the image is erased, it can then be immediately plotted in the new position. The times required to plot and erase the shape, however, are directly determined by the speed of the image subroutine. If the subroutine is slow, the plot and erase times are long, and the image appears to flicker as it moves across the screen.

Representing Shapes

To understand why the standard Apple shape subroutine is too slow for most animation purposes, you must know how the subroutine works and especially how it expects a shape to be represented in memory. A shape is represented by a series of vectors in memory, with each vector specifying if a given pixel should be turned on. It also specifies which of the four adjacent pixels should be addressed by the next vector. This scheme best suits the representation of simple, single-line shapes such as those in figure 1. Unfortunately, if a shape must be filled in or if the shape has any detail drawn within its boundaries, as in figure 2, the shape's representation is awkward and inefficient at best. In these cases it is often necessary to overplot points and use many vectors that specify motion without plotting. Moreover, if the shape is large, the sheer size of

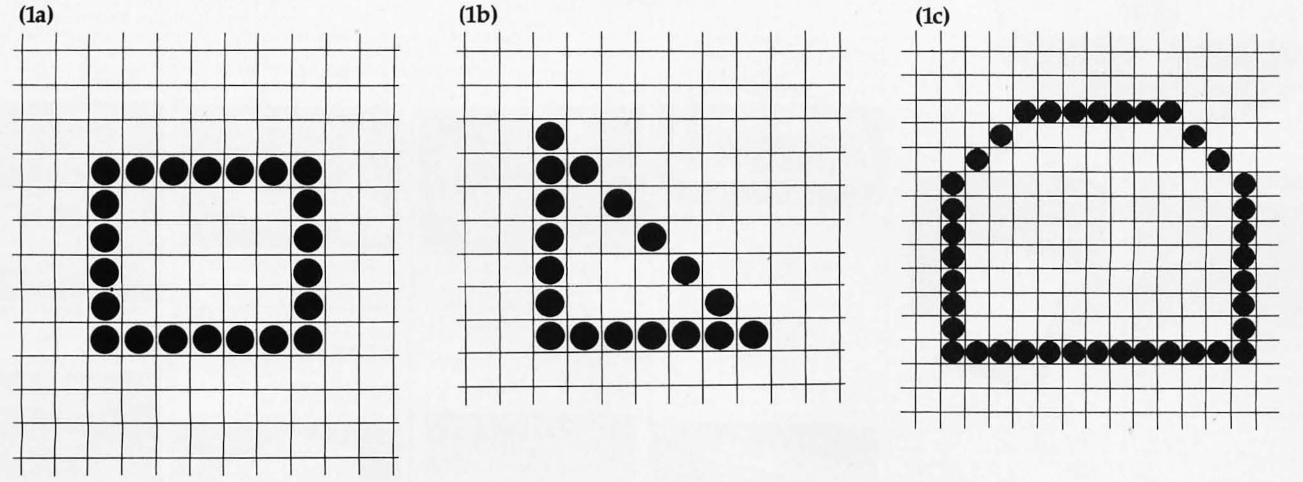

Figure 1: *Because they are easily represented in memory by a series of vectors, these simple single-line closed shapes are suitable for display by the standard Apple shape subroutine on the hi-res graphics screen.*

the vector table becomes unwieldy. When the time comes to plot these shapes, the subroutine steps through the table, and each vector takes up a certain amount of time. If the vector table represents the shape inefficiently, the end result is wasted time in the plotting of the shape.

Similarly contributing to the slow speed of the shape subroutine is the inclusion of scaling and rotation factors. In order to plot a shape, a calling routine must specify a scaling factor that determines the plotted shape's size (actual size, double size, triple size, etc.) and a rotation factor that determines the angle through which the shape is rotated before plotting. Although these factors are useful in some applications, using them with shape animation rarely produces satisfying results, and these calculations slow the subroutine considerably.

A New Shape Subroutine

After realizing that the speed bottleneck in my programs was caused by the shape subroutine, I went about designing my own subroutine with two criteria in mind. First, the subroutine had to be high speed to minimize image flicker, and second, the method of representing a shape in memory had to allow complicated images to be plotted as quickly as simple single-line shapes of the same overall size. One way to meet these criteria is to use a bit picture to represent the shape in memory. In other words, the shape is represented in main memory in the same form in which it is ultimately represented in the hi-res screen memory when the shape is plotted on the hi-res screen. Plotting the shape is then simple and fast: the bytes representing the shape in main memory need only be transferred to the hi-res screen memory. I used this technique in writing a fast shape subroutine suitable for animation.

The table of bytes that make up the bit picture is called the shape table.

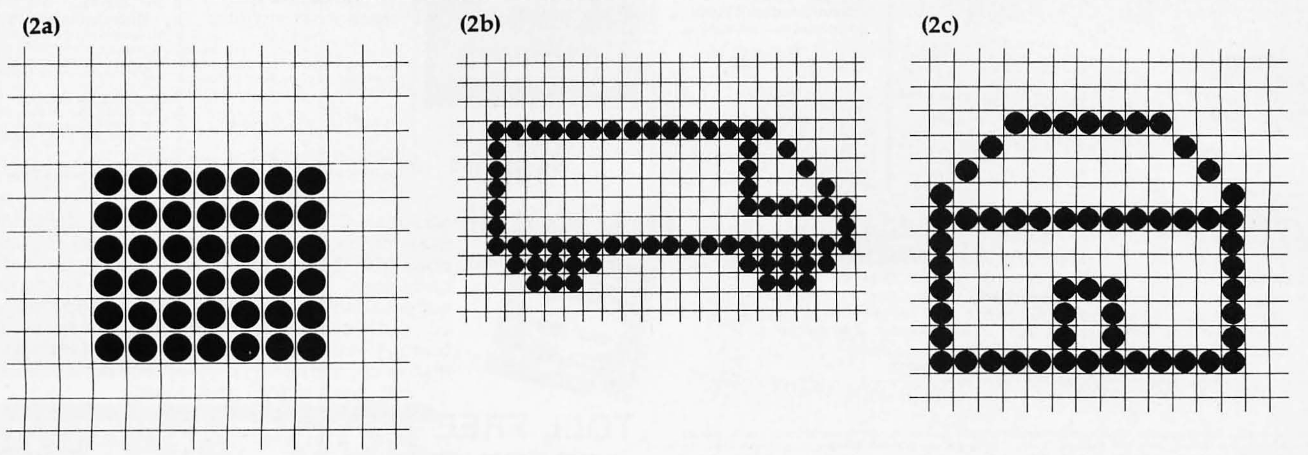

Figure 2: *The detail within these shapes makes their representation as vectors in memory inefficient; therefore, the standard Apple shape subroutine is neither well suited nor easy to use for the display of these shapes on the hi-res screen.*

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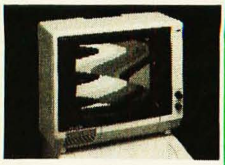

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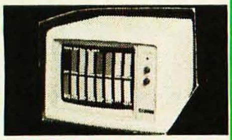

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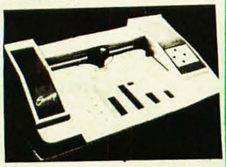

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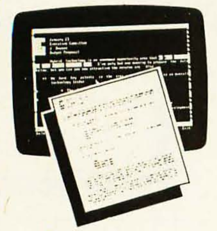
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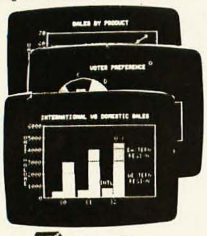

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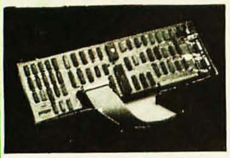

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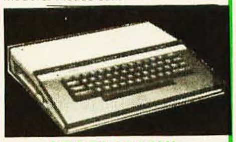

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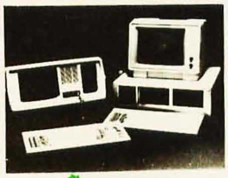

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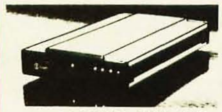

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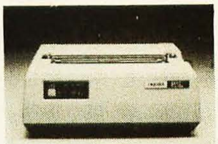

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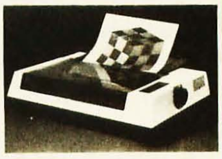

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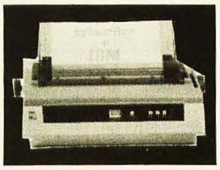

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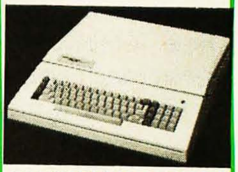

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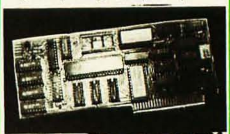

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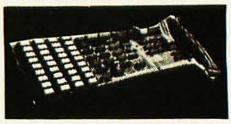

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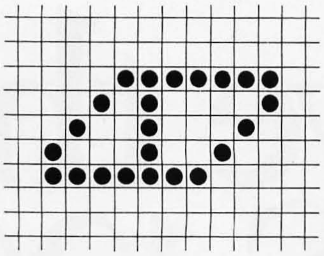
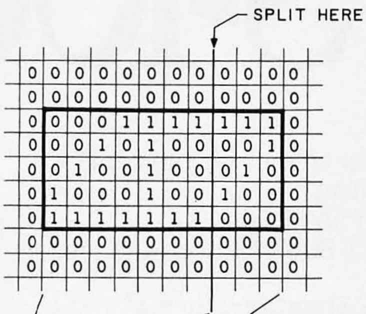


(3b)




```
0001111   1110000
0010100   0010000
0100100   0100000
1000100   1000000
1111111   0000000
          ADDED
          ZEROS
```

(3c)

```
1111000   0000111
0010100   0000100
0010010   0000010
0010001   0000001
1111111   0000000
```

(3d)

```
78   07
14   04
12   02
11   01
7F   00
```

Figure 3: *To form a shape table, start by drawing the desired shape on graph paper, using 1s and 0s to represent "on" and "off" pixels (3a). Next, split each line of bits into 7-bit groups, padding the last group of each line with 0s if necessary (3b). Then, reverse the order of the binary digits in each 7-bit group (3c) and convert to hexadecimal (3d). Later you must add height and width bytes as described in the text.*

A shape table is most easily formed through the use of the shape-editor program presented later in this article. To form a shape table manually, start by drawing the shape on a piece of graph paper with one pixel per square, as in figure 3a. Use 1s to represent on pixels and 0s to represent off pixels. Draw the smallest possible rectangle that still encloses

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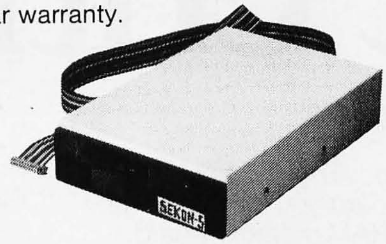

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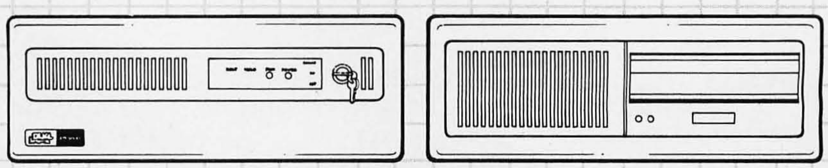

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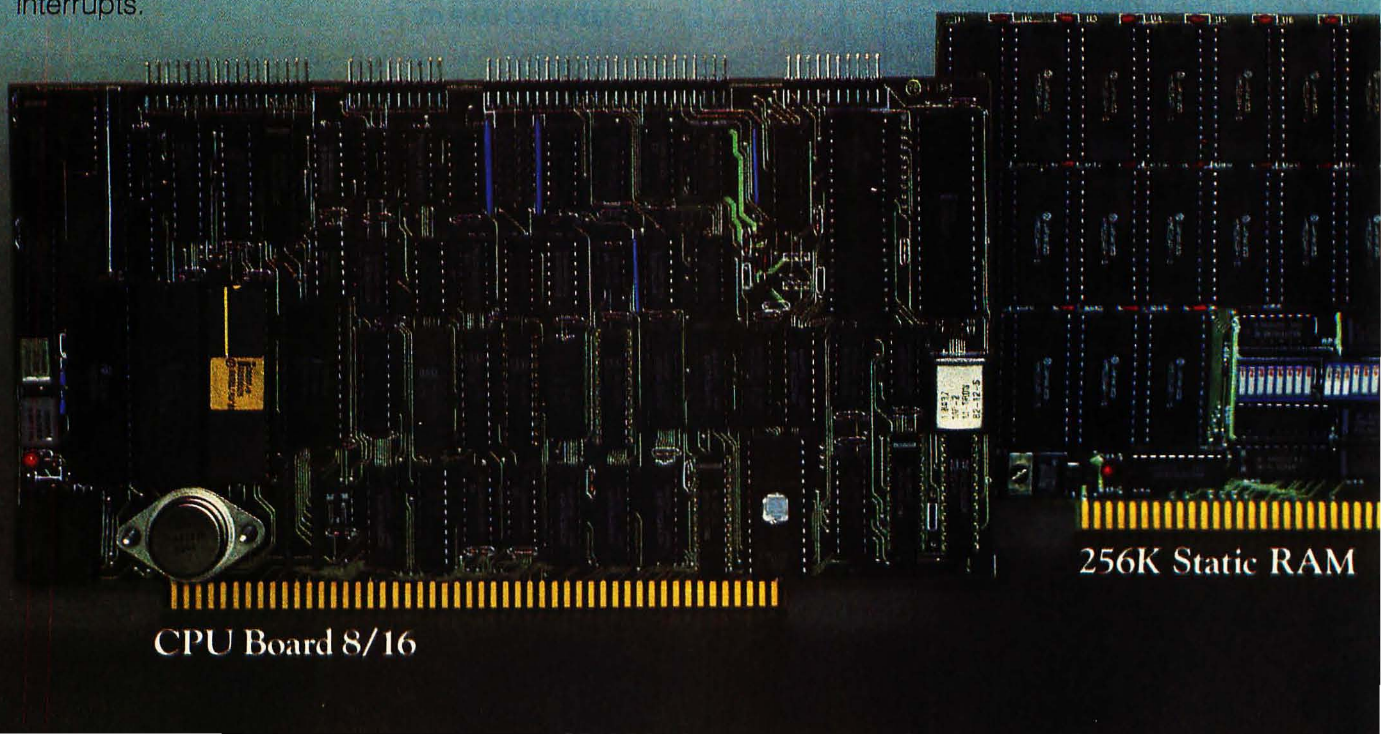

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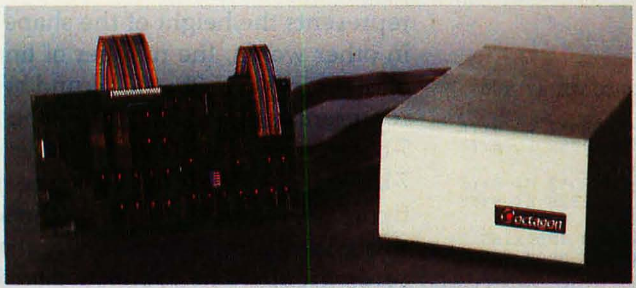

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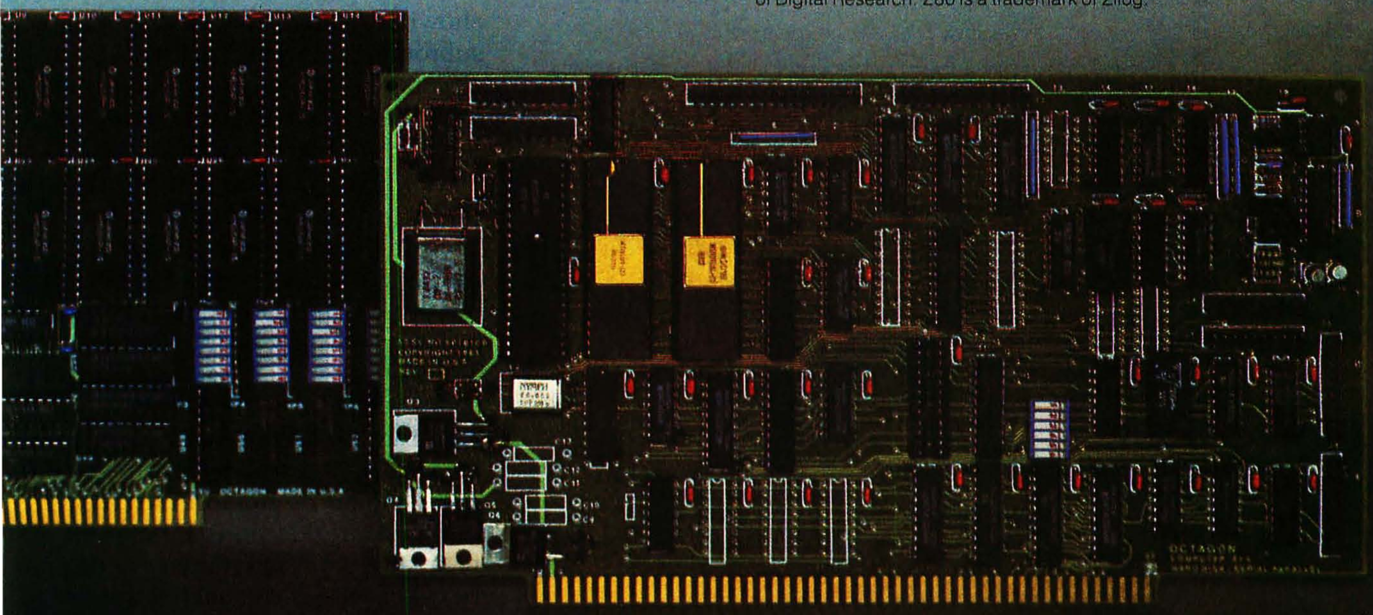

Hard Disk Controller

Listing 1: *A fast shape subroutine that plots high-resolution shapes on the Apple II.*

```
0000:                        OBJ $1B00
1B00:                        ORG $1B00         ;ASSEMBLY LOCATION
1B00:           ******************************************************
1B00:           * SHAPE SUBROUTINE WRITTEN BY RICHARD T. SIMONI, JR.  *
1B00:           *                                                     *
1B00:           * SHAPE WORKS BY STEPPING THROUGH THE USER TABLE ONE  *
1B00:           * HI-RES LINE AT A TIME, SHIFTING THE BIT PATTERN THE *
1B00:           * APPROPRIATE NUMBER OF TIMES (DEPENDING ON THE       *
1B00:           * X-COORDINATE PASSED IN THE X- AND Y-REGISTERS), AND *
1B00:           * MOVING THE PATTERN TO THE PROPER PLACE IN THE HI-RES *
1B00:           * SCREEN MEMORY.                                      *
1B00:           ******************************************************
1B00:           STARTZ      EQU $19           ;START OF LINE STORAGE
1B00:           YCOORD      EQU $E3           ;LINE COUNTER
1B00:           START       EQU $EB           ;USER TABLE POINTER
1B00:           ADDRL       EQU $ED           ;1ST SCREEN BYTE TO USE
1B00:           ADDRH       EQU $EE           ;  IN LINE YCOORD
1B00:           ADDRADD     EQU $EF           ;OFFSET FROM LEFT BYTE
1B00:           SHFTNUM     EQU $F9           ;NUMBER OF SHIFTS
1B00:           ENDLN       EQU $FD           ;LAST LINE + 1
1B00:           WIDTH       EQU $FB           ;WIDTH OF USER TABLE
1B00:           INDEX       EQU $FC           ;POINTER IN USER TABLE
1B00:           *
1B00:           * DIVIDE X-COORD BY 7 TO GET BYTE OFFSET FROM LEFTMOST
1B00:           * BYTE IN ANY HI-RES LINE. REMAINDER WILL BE CORRECT
1B00:           * NUMBER OF SHIFTS TO PERFORM ON BIT PATTERN.
1B00:           * DIVISION IS PERFORMED USING LOOKUP TABLE FOR SPEED.
1B00:           *
1B00: 85 E3                 STA YCOORD        ;STORE Y-COORD (COUNTER)
1B02: 8A                    TXA
1B03: 0A                    ASL A
1B04: AA                    TAX
1B05: 98                    TYA
1B06: 2A                    ROL A
1B07: A8                    TAY               ;MULTIPLY X-COORD BY TWO
1B08: 18                    CLC
1B09: 8A                    TXA               ;A-REG = X-COORD*2 LO-BYTE
1B0A: 69 83                 ADC #>QUOTBL      ;ADD TABLE ADDRESS LO-BYTE
1B0C: 85 ED                 STA ADDRL         ;STORE RESULT
1B0E: 98                    TYA               ;A-REG = X-COORD*2 HI-BYTE
1B0F: 69 1B                 ADC #<QUOTBL      ;ADD TABLE ADDRESS HI-BYTE
1B11: 85 EE                 STA ADDRH         ;STORE RESULT
1B13: A0 00                 LDY #$00          ;ZERO Y-REG FOR INDEXING
1B15: B1 ED                 LDA (ADDRL),Y     ;LOAD X-COORD/7 FROM TABLE
1B17: 85 EF                 STA ADDRADD       ;ADDRADD = X-COORD/7
1B19: C8                    INY               ;REMAINDER FOLLOWS IN TABLE
1B1A: B1 ED                 LDA (ADDRL),Y     ;LOAD REMAINDER FROM TABLE
1B1C: 85 F9                 STA SHFTNUM       ;SHFTNUM = REMAINDER
1B1E:           *
1B1E:           * INITIALIZE LOCATIONS ENDLN AND WIDTH. ENDLN CONTAINS
1B1E:           * THE Y-COORD OF THE LAST LINE + 1. WIDTH CONTAINS THE
1B1E:           * WIDTH (IN BYTES) OF EACH LINE.
1B1E:           *
1B1E: A5 E3                 LDA YCOORD
1B20: A0 00                 LDY #$00
1B22: 18                    CLC
1B23: 71 EB                 ADC (START),Y
1B25: 85 FD                 STA ENDLN         ;ENDLN = Y-COORD+LENGTH
1B27: C8                    INY
1B28: B1 EB                 LDA (START),Y
1B2A: 85 FB                 STA WIDTH         ;GET & STORE WIDTH
1B2C: C8                    INY
1B2D: 84 FC                 STY INDEX         ;INDEX=2
1B2F:           *
1B2F:           * LOOP1 IS THE LOOP THAT IS CYCLED THROUGH ONCE FOR EACH
1B2F:           * LINE ON THE HI-RES SCREEN
1B2F:           *
1B2F: A6 FB     LOOP1       LDX WIDTH         ;X-REG=0 (COUNTER)
1B31: A4 FC                 LDY INDEX
1B33:           *
1B33:           * MOVE BYTES FOR LINE YCOORD FROM USER TABLE TO ZERO PAGE
1B33:           *
1B33: B1 EB     LOOP2       LDA (START),Y     ;GET XTH BYTE OF LINE
1B35: 95 19                 STA STARTZ,X      ;STORE IN STARTZ+X
1B37: C8                    INY
1B38: CA                    DEX               ;MOVED ALL BYTES YET?
1B39: D0 F8                 BNE LOOP2         ;NO, LOOP
1B3B: 86 19                 STX STARTZ        ;STARTZ=0
1B3D: 84 FC                 STY INDEX
1B3F:           *
1B3F:           * SHIFT THE BIT PATTERN SHFTNUM TIMES
1B3F:           *
1B3F: A4 F9                 LDY SHFTNUM       ;IS SHFTNUM=0?
1B41: F0 16                 BEQ SKIP          ;YES, SKIP THE SHIFTING
1B43: 18        LOOP3       CLC               ;NO, START SHIFTING
1B44: A6 FB                 LDX WIDTH
1B46: 08                    PHP               ;KEEP STACK IN ORDER
1B47: 28        LOOP4       PLP               ;RESTORE CARRY
1B48: B5 19                 LDA STARTZ,X      ;LOAD ORIGINAL PATTERN
1B4A: 2A                    ROL A
```

Listing 1 continued on page 300

the entire figure. Then split each line of binary digits enclosed by the rectangle into 7-bit groups. If, as in figure 3b, the *last* group doesn't have a full 7 bits, add enough 0s to the end of each line to bring the total up to 7 bits. Due to limitations to the subroutine, no more than seven 7-bit groups per line are allowed. Reverse the order of the bits in each group, as shown in figure 3c. Convert each new 7-bit group into its hexadecimal or decimal equivalent, whichever is preferred (figure 3d shows the hexadecimal equivalent) and, reading across each line left to right from the top to the bottom line, recopy the list of numbers in table (linear) form. The table is now complete except for two bytes that belong at the top of the table. The first of these bytes represents the height of the shape—in other words, the number of lines of digits in figure 3b; the second byte represents the width of the shape in 7-bit groups—that is, the number of 7-bit groups used in each line in figure 3b. As previously mentioned, this width should be no more than seven groups. The complete table in hexadecimal form for the sample shape used in figure 3 is as follows:

05 02 78 07 14 04 12 02
11 01 7F 00

The shape subroutine itself is shown in listing 1, and the lookup tables used by the subroutine are shown in listing 2. Before calling the subroutine, several registers and memory locations must be set up with certain parameters, including the hi-res screen coordinates of the pixel where the upper left corner of the bit picture should be positioned. The low-order byte of the *x*-coordinate should be placed in the X register, and the corresponding high-order byte of the *x*-coordinate (either 1 or 0) goes in the Y register. The *y*-coordinate goes in the A register (accumulator). The low- and high-order bytes of the shape-table starting address should be stored in hexadecimal memory locations EB and EC, respectively. The subroutine can then be called with the usual JSR instruc-

Text continued on page 303

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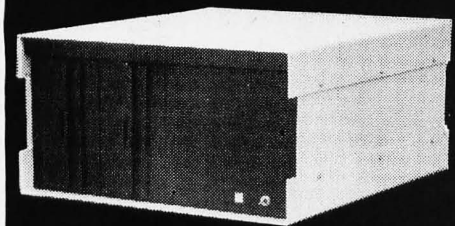

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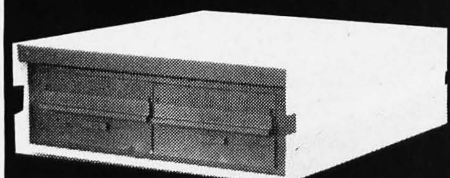

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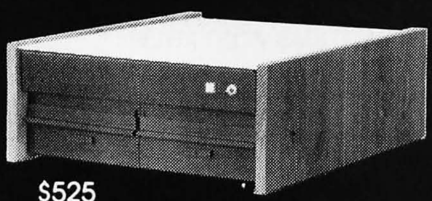

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Listing 1 continued:

```
1B4B: 2A                     ROL A           ;ROTATE LEFT TWICE
1B4C: 08                     PHP             ;SAVE CARRY
1B4D: 4A                     LSR A           ;SHIFT RIGHT ONCE
1B4E: 95 19                  STA STARTZ,X    ;STORE SHIFTED PATTERN
1B50: CA                     DEX
1B51: E0 FF                  CPX #$FF        ;ROTATED EACH BYTE?
1B53: D0 F2                  BNE LOOP4       ;NO, LOOP
1B55: 28                     PLP             ;KEEP STACK IN ORDER
1B56: 88                     DEY
1B57: D0 EA                  BNE LOOP3       ;LOOP IF Y<>0
1B59:             *
1B59:             * CALCULATE HI-RES SCREEN ADDRESS FOR FIRST BYTE TO
1B59:             * BE USED IN LINE YCOORD
1B59:             *
1B59: A4 E3       SKIP       LDY YCOORD
1B5B: B9 B3 1D               LDA LOSTRT,Y
1B5E: 18                     CLC
1B5F: 65 EF                  ADC ADDRADD
1B61: 85 ED                  STA ADDRL
1B63: B9 73 1E               LDA HISTRT,Y
1B66: 69 00                  ADC #$00
1B68: 85 EE                  STA ADDRH       ;GET ADDR FOR 1ST BYTE
1B6A:             *
1B6A:             * MOVE SHIFTED BYTES FROM ZERO PAGE TO HI-RES SCREEN
1B6A:             * MEMORY. FOR NON-EXCLUSIVE-OR PLOTTING, CHANGE
1B6A:             * 'EOR (ADDRL),Y' TO 'ORA (ADDRL),Y' (OPCODE $11).
1B6A:             *
1B6A: A0 00                  LDY #$00
1B6C: A6 FB                  LDX WIDTH
1B6E: B5 19       LOOP5      LDA STARTZ,X
1B70: 51 ED                  EOR (ADDRL),Y
1B72: 91 ED                  STA (ADDRL),Y   ;PLOT BYTE ON SCREEN
1B74: C8                     INY
1B75: CA                     DEX
1B76: E0 FF                  CPX #$FF        ;THROUGH PLOTTING LINE?
1B78: D0 F4                  BNE LOOP5       ;NO, LOOP
1B7A: E6 E3                  INC YCOORD      ;YES, GO TO NEXT LINE
1B7C: A5 E3                  LDA YCOORD
1B7E: C5 FD                  CMP ENDLN       ;MORE LINES?
1B80: D0 AD                  BNE LOOP1       ;YES, LOOP
1B82: 60                     RTS             ;NO, RETURN
1B83:             QUOTBL     EQU *
1B83:             LOSTRT     EQU *+560
1B83:             HISTRT     EQU *+752

*** SUCCESSFUL ASSEMBLY: NO ERRORS
```

Listing 2: *Lookup tables used by the listing 1 subroutine.*

```
1B83- 00 00 00 01 00 02 00 03 00 04 00 05 00
1B90- 06 01 00 01 01 01 02 01 03 01 04 01 05 01 06 02
1BA0- 00 02 01 02 02 02 03 02 04 02 05 02 06 03 00 03
1BB0- 01 03 02 03 03 03 04 03 05 03 06 04 00 04 01 04
1BC0- 02 04 03 04 04 04 05 04 06 05 00 05 01 05 02 05
1BD0- 03 05 04 05 05 05 06 06 00 06 01 06 02 06 03 06
1BE0- 04 06 05 06 06 07 00 07 01 07 02 07 03 07 04 07
1BF0- 05 07 06 08 00 08 01 08 02 08 03 08 04 08 05 08
1C00- 06 09 00 09 01 09 02 09 03 09 04 09 05 09 06 0A
1C10- 00 0A 01 0A 02 0A 03 0A 04 0A 05 0A 06 0B 00 0B
1C20- 01 0B 02 0B 03 0B 04 0B 05 0B 06 0C 00 0C 01 0C
1C30- 02 0C 03 0C 04 0C 05 0C 06 0D 00 0D 01 0D 02 0D
1C40- 03 0D 04 0D 05 0D 06 0E 00 0E 01 0E 02 0E 03 0E
1C50- 04 0E 05 0E 06 0F 00 0F 01 0F 02 0F 03 0F 04 0F
1C60- 05 0F 06 10 00 10 01 10 02 10 03 10 04 10 05 10
1C70- 06 11 00 11 01 11 02 11 03 11 04 11 05 11 06 12
1C80- 00 12 01 12 02 12 03 12 04 12 05 12 06 13 00 13
1C90- 01 13 02 13 03 13 04 13 05 13 06 14 00 14 01 14
1CA0- 02 14 03 14 04 14 05 14 06 15 00 15 01 15 02 15
1CB0- 03 15 04 15 05 15 06 16 00 16 01 16 02 16 03 16
1CC0- 04 16 05 16 06 17 00 17 01 17 02 17 03 17 04 17
1CD0- 05 17 06 18 00 18 01 18 02 18 03 18 04 18 05 18
1CE0- 06 19 00 19 01 19 02 19 03 19 04 19 05 19 06 1A
1CF0- 00 1A 01 1A 02 1A 03 1A 04 1A 05 1A 06 1B 00 1B
1D00- 01 1B 02 1B 03 1B 04 1B 05 1B 06 1C 00 1C 01 1C
1D10- 02 1C 03 1C 04 1C 05 1C 06 1D 00 1D 01 1D 02 1D
1D20- 03 1D 04 1D 05 1D 06 1E 00 1E 01 1E 02 1E 03 1E
1D30- 04 1E 05 1E 06 1F 00 1F 01 1F 02 1F 03 1F 04 1F
1D40- 05 1F 06 20 00 20 01 20 02 20 03 20 04 20 05 20
1D50- 06 21 00 21 01 21 02 21 03 21 04 21 05 21 06 22
1D60- 00 22 01 22 02 22 03 22 04 22 05 22 06 23 00 23
1D70- 01 23 02 23 03 23 04 23 05 23 06 24 00 24 01 24
1D80- 02 24 03 24 04 24 05 24 06 25 00 25 01 25 02 25
1D90- 03 25 04 25 05 25 06 26 00 26 01 26 02 26 03 26
1DA0- 04 26 05 26 06 27 00 27 01 27 02 27 03 27 04 27
1DB0- 05 27 06 00 00 00 00 00 00 00 00 80 80 80 80 80
1DC0- 80 80 80 00 00 00 00 00 00 00 00 80 80 80 80 80
1DD0- 80 80 80 00 00 00 00 00 00 00 00 80 80 80 80 80
1DE0- 80 80 80 00 00 00 00 00 00 00 00 80 80 80 80 80
1DF0- 80 80 80 28 28 28 28 28 28 28 28 A8 A8 A8 A8 A8
1E00- A8 A8 A8 28 28 28 28 28 28 28 28 A8 A8 A8 A8 A8
1E10- A8 A8 A8 28 28 28 28 28 28 28 28 A8 A8 A8 A8 A8
1E20- A8 A8 A8 28 28 28 28 28 28 28 28 A8 A8 A8 A8 A8
1E30- A8 A8 A8 50 50 50 50 50 50 50 50 D0 D0 D0 D0 D0
1E40- D0 D0 D0 50 50 50 50 50 50 50 50 D0 D0 D0 D0 D0
```

Listing 2 continued on page 303

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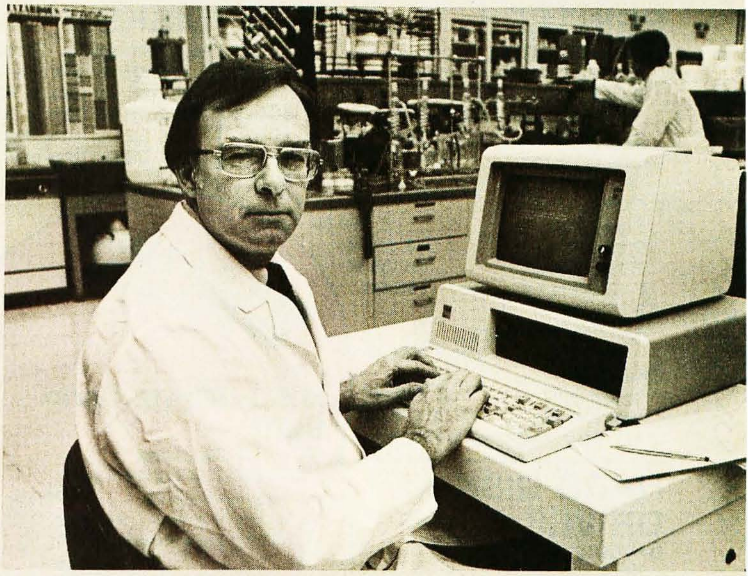

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(1a)

Coordinate	6502 Register
x low-order byte	X
x high-order byte	Y
y	A

(1b)

Address Byte	Memory Location
low-order byte	EB
high-order byte	EC

Table 1: *Summary of parameters that must be set up prior to calling the shape subroutine: coordinates of upper left corner of bit picture (1a) and starting address (hexadecimal) of shape table (1b).*

Text continued from page 298:

tion. A summary of the parameter setup is given in table 1.

The subroutine works by taking the exclusive-OR of each affected bit in page-1 hi-res screen memory with the corresponding bit of the bit picture. This exclusive-OR plotting has several advantages. First, a color need not be specified; the shape is drawn by calling the subroutine once and is erased by simply calling it again with the same screen coordinates. Second, any shape drawn using exclusive-OR plotting is nondestructive; that is, whatever the shape happens to plot over is restored when the shape is erased. This property can be used to form interesting backgrounds that need not be redrawn after shapes are plotted and moved on top of them. Cross-hair cursors are also free to move around without destroying the screen's previous contents.

Several details about the subroutine need to be explained. Zero page (hexadecimal locations 00 through FF) of memory is used for temporary storage; the particular locations used were chosen to avoid destruction of locations used by the Apple Monitor, Applesoft, Integer Basic, and the DOS (disk operating system). The subroutine does not operate correctly without the tables shown in listing 2. These tables may be stored anywhere in memory, but are best located immediately after the subroutine in memory. Three pertinent

Text continued on page 306

Listing 2 continued:

```
1E50- D0 D0 D0 50 50 50 50 50 50 50 50 D0 D0 D0 D0 D0
1E60- D0 D0 D0 50 50 50 50 50 50 50 50 D0 D0 D0 D0 D0
1E70- D0 D0 D0 20 24 28 2C 30 34 38 3C 20 24 28 2C 30
1E80- 34 38 3C 21 25 29 2D 31 35 39 3D 21 25 29 2D 31
1E90- 35 39 3D 22 26 2A 2E 32 36 3A 3E 22 26 2A 2E 32
1EA0- 36 3A 3E 23 27 2B 2F 33 37 3B 3F 23 27 2B 2F 33
1EB0- 37 3B 3F 20 24 28 2C 30 34 38 3C 20 24 28 2C 30
1EC0- 34 38 3C 21 25 29 2D 31 35 39 3D 21 25 29 2D 31
1ED0- 35 39 3D 22 26 2A 2E 32 36 3A 3E 22 26 2A 2E 32
1EE0- 36 3A 3E 23 27 2B 2F 33 37 3B 3F 23 27 2B 2F 33
1EF0- 37 3B 3F 20 24 28 2C 30 34 38 3C 20 24 28 2C 30
1F00- 34 38 3C 21 25 29 2D 31 35 39 3D 21 25 29 2D 31
1F10- 35 39 3D 22 26 2A 2E 32 36 3A 3E 22 26 2A 2E 32
1F20- 36 3A 3E 23 27 2B 2F 33 37 3B 3F 23 27 2B 2F 33
1F30- 37 3B 3F
```

Listing 3: *This shape-editor program forms a shape table directly from a high-resolution screen image.*

```
100  TEXT : HOME : POKE  - 16298,0: POKE  - 16300,0
110  RESTORE : FOR I = 768 TO 774: READ J: POKE I,J: NEXT I: POKE 232,0: POKE 23
     3,3: DATA  1,0,3,0,45,5,0
120  DIM S%(105),T%(212)
130 XMAX = 42:YMAX = 35:ML = 101:MT = 10
140 H$ = "0123456789ABCDEF"
150 D$ =  CHR$ (4)
160  GOSUB 3100: GOSUB 3300: GOSUB 3400
400  REM  SHOW CURSOR POSITION ON GRID
410  XDRAW 1 AT CL + 1,CT + 3
420  REM  WAIT FOR KEYBOARD COMMAND
430 Q =  PEEK ( - 16384): IF Q < 128 THEN 430
440  POKE  - 16368,0:Q = Q - 128
500  REM
501  REM    CURSOR MOVEMENT COMMANDS
502  REM
510  IF Q <  >  ASC ("I") THEN 550
520  XDRAW 1 AT CL + 1,CT + 3
530  IF Y > 1 THEN Y = Y - 1:CT = CT - 4
540  GOTO 410
550  IF Q <  >  ASC ("M") THEN 590
560  XDRAW 1 AT CL + 1,CT + 3
570  IF Y < YMAX THEN Y = Y + 1:CT = CT + 4
580  GOTO 410
590  IF Q <  >  ASC ("J") THEN 630
600  XDRAW 1 AT CL + 1,CT + 3
610  IF X > 1 THEN X = X - 1:CL = CL - 4
620  GOTO 410
630  IF Q <  >  ASC ("K") THEN 700
640  XDRAW 1 AT CL + 1,CT + 3
650  IF X < XMAX THEN X = X + 1:CL = CL + 4
660  GOTO 410
700  REM
701  REM    PLOT COMMAND
702  REM
710  IF Q <  >  ASC ("P") THEN 810
720 ELE =  INT ((X - 1) / 14) + 3 * (Y - 1)
730 BIT = (X - 1) -  INT ((X - 1) / 14) * 14
740 A =  INT (S%(ELE) / 2 ^ BIT)
750  IF A / 2 <  >  INT (A / 2) THEN 810
760 S%(ELE) = S%(ELE) + 2 ^ BIT
770  FOR I = 2 TO 4: XDRAW 1 AT CL + 1,CT + I: NEXT I
780  HCOLOR= 7: HPLOT 29 + X,62 + Y
790  GOTO 430
800  REM
801  REM   ERASE COMMAND
802  REM
810  IF Q <  >  ASC ("E") THEN 900
820 ELE =  INT ((X - 1) / 14) + 3 * (Y - 1)
830 BIT = (X - 1) -  INT ((X - 1) / 14) * 14
840 A =  INT (S%(ELE) / 2 ^ BIT)
850  IF A / 2 =  INT (A / 2) THEN 900
860 S%(ELE) = S%(ELE) - 2 ^ BIT
870  FOR I = 2 TO 4: XDRAW 1 AT CL + 1,CT + I: NEXT I
880  HCOLOR= 0: HPLOT 29 + X,62 + Y
890  GOTO 430
900  REM
901  REM   CLEAR SCREEN COMMAND
902  REM
910  IF Q <  >  ASC ("C") THEN 1030
920  XDRAW 1 AT CL + 1,CT + 3
930  VTAB 23: PRINT "SURE YOU WANT TO ERASE THE SCREEN?"
940  GOSUB 3500
950  VTAB 22: CALL  - 958: IF Q <  >  ASC ("Y") THEN 410
960  FOR I = 0 TO 105:S%(I) = 0: NEXT I
970  GOSUB 3300: GOSUB 3400: GOTO 410
1000  REM
1010  REM   TABLE COMMAND
1020  REM
1030  IF Q <  >  ASC ("T") THEN 1520
1040  VTAB 23: PRINT "SET CURSOR TO TOP LEFT CORNER OF": PRINT "DESIRED BIT MAP
      AND HIT RETURN";
1050 LS = 1
```

Listing 3 continued on page 304

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Listing 3 continued:

```
1060  GOTO 430
1070 PL = X:PT = Y
1080  VTAB 22: CALL  - 958: PRINT : PRINT "SET CURSOR TO BOTTOM RIGHT CORNER OF"
     : PRINT "DESIRED BIT MAP AND HIT RETURN";
1090 L5 = 2
1100  GOTO 430
1110 PR = X:PB = Y:L5 = 0
1120  XDRAW 1 AT CL + 1,CT + 3
1130  VTAB 22: CALL  - 958
1140  IF PL > PR OR PT > PB THEN  VTAB 23: HTAB 1: POKE 50,63: PRINT "ILLEGAL BI
     T MAP CORNERS": POKE 50,255: FOR I = 1 TO 2000: NEXT I: VTAB 22: CALL  - 95
     8: GOTO 410
1150  VTAB 23: HTAB 1: PRINT "NOW FORMING SHAPE TABLE"
1160  FOR I = 0 TO 212:T%(I) = 0: NEXT I
1170 L = PB - PT + 1:W = (PR - PL + 1) / 7: IF W <  >  INT (W) THEN W =  INT (W)
      + 1
1180 T%(0) = L:T%(1) = W:N = 2:Q = 0
1190  FOR Y = PT TO PB
1200  FOR X = PL TO PL + W * 7 - 1
1210  IF X > PR THEN BN = 0: GOTO 1250
1220 ELE =  INT ((X - 1) / 14) + 3 * (Y - 1)
1230 BIT = (X - 1) -  INT ((X - 1) / 14) * 14
1240 BN = 0:A =  INT (S%(ELE) / 2 ^ BIT): IF  INT (A / 2) <  > A / 2 THEN BN = 1
1250  IF BN = 1 THEN T%(N) = T%(N) + 2 ^ Q
1260 Q = Q + 1: IF Q = 7 THEN Q = 0:N = N + 1
1270  NEXT X: NEXT Y
1280  HOME : POKE  - 16303,0
1290  VTAB 2: PRINT "DO YOU WANT TO SEE THE TABLE IN HEX": PRINT "   OR IN DECIM
     AL?": PRINT : PRINT
1300  GOSUB 3500
1310  IF Q <  >  ASC ("D") AND Q <  >  ASC ("H") THEN 1280
1320 Z = 0: FOR I = 0 TO L * W + 1
1330 Z = Z + 1
1340  IF Q =  ASC ("D") THEN  PRINT  TAB( Z * 4);T%(I);: GOTO 1360
1350  PRINT  TAB( Z * 3); MID$ (H$, INT (T%(I) / 16) + 1,1); MID$ (H$,T%(I) -  I
     NT (T%(I) / 16) * 16 + 1,1);
1360  IF Z = 8 THEN Z = 0: PRINT
1370  NEXT I
1380  PRINT : PRINT : IF  PEEK (37) < 21 THEN  POKE 34, PEEK (37)
1390  PRINT "DO YOU WANT TO SAVE THE OBJECT TABLE": PRINT "   ON DISK?"
1400  GOSUB 3500
1410  IF Q <  >  ASC ("Y") THEN 1470
1420  PRINT : PRINT "WHAT DO YOU WANT TO NAME": INPUT "   THE FILE? ";N$
1430  FOR I = 0 TO L * W + 1: POKE 16384 + I,T%(I): NEXT I
1440  PRINT D$;"BSAVE";N$;",A$4000,L";L * W + 2
1450  PRINT "FILE SAVED USING NAME ";N$
1460  PRINT : PRINT : GOTO 1390
1470  POKE 34,0: HOME : VTAB 2: PRINT "DO YOU WANT TO RETURN TO THE": PRINT "
     SCREEN EDIT MODE?"
1480  GOSUB 3500
1490  IF Q <  >  ASC ("Y") THEN 2260
1500  GOSUB 3100: POKE  - 16304,0: GOSUB 3310: GOTO 410
1510  REM  'RETURN' PSEUDO-COMMAND
1520  IF Q <  > 13 THEN 1600
1530  ON L5 + 1 GOTO 430,1070,1110
1600  REM
1601  REM   SAVE TABLE COMMAND
1602  REM
1610  IF Q <  >  ASC ("S") THEN 1800
1620  XDRAW 1 AT CL + 1,CT + 3
1630  VTAB 23: INPUT "FILE NAME FOR SAVE? ";N$
1640  VTAB 24: PRINT "NOW SCANNING IMAGE";: HTAB 1
1650 Z1 = 0
1660  IF S%(Z1) = 0 AND Z1 < 105 THEN Z1 = Z1 + 1: GOTO 1660
1670 Z2 = 105
1680  IF S%(Z2) = 0 AND Z2 > 0 THEN Z2 = Z2 - 1: GOTO 1680
1690  IF Z1 > Z2 THEN Z1 = 0:Z2 = 1
1700  VTAB 24: PRINT "NOW SAVING IMAGE TO DISK";: VTAB 23: PRINT
1710  PRINT D$;"OPEN";N$: PRINT D$;"WRITE";N$
1720  PRINT Z1: PRINT Z2
1730  FOR I = Z1 TO Z2
1740  PRINT S%(I)
1750  NEXT I
1760  PRINT D$;"CLOSE";N$
1770  VTAB 22: CALL  - 958: GOTO 410
1800  REM
1801  REM   LOAD TABLE COMMAND
1802  REM
1810  IF Q <  >  ASC ("G") THEN 2100
1820  XDRAW 1 AT CL + 1,CT + 3
1830  VTAB 23: PRINT "SURE YOU WANT TO LOAD?"
1840  GOSUB 3500
1850  VTAB 22: CALL  - 958: IF Q <  >  ASC ("Y") THEN 410
1860  VTAB 23: INPUT "FILE NAME FOR LOAD? ";N$
1870  PRINT D$;"OPEN";N$: PRINT D$;"READ";N$
1880  INPUT Z1: INPUT Z2
1890  FOR I = 0 TO Z1:S%(I) = 0: NEXT I: FOR I = Z2 TO 105:S%(I) = 0: NEXT I
1900  FOR I = Z1 TO Z2
1910  INPUT S%(I)
1920  NEXT I
1930  PRINT D$;"CLOSE";N$
1940  GOSUB 3300: GOSUB 3400
1950  VTAB 22: CALL  - 958: VTAB 23: PRINT "NOW RETRACING IMAGE ON SCREEN"
1960 ELE = Z1:BIT = 0:CL = ML + 4 * ((ELE -  INT (ELE / 3) * 3) * 14)
1970 CT = MT + 4 *  INT (ELE / 3)
1980 A =  INT (S%(ELE) / 2 ^ BIT): IF  INT (A / 2) = A / 2 THEN 2000
1990  FOR I = 2 TO 4: XDRAW 1 AT CL + 1,CT + I: NEXT I: HPLOT 30 + (CL - ML) / 4
     ,63 + (CT - MT) / 4
```

Listing 3 continued on page 306

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Listing 3 continued:

```
2000 CL = CL + 4:BIT = BIT + 1: IF BIT <  > 14 THEN 1980
2010  IF ELE >  = Z2 THEN  GOSUB 3310: GOTO 410
2020 BIT = 0:ELE = ELE + 1
2030  IF ELE / 3 =  INT (ELE / 3) THEN CL = ML:CT = CT + 4
2040  GOTO 1980
2100  REM
2101  REM   HELP COMMAND
2102  REM
2110  IF Q <  >  ASC ("H") AND Q <  >  ASC ("/") AND Q <  >  ASC ("?") THEN 2200
2120  VTAB 21: CALL  - 958: POKE  - 16303,0
2130  GOSUB 3170
2140  POKE  - 16304,0
2150  VTAB 20: PRINT : CALL  - 958: HTAB 2: PRINT "ACTUAL SIZE";: HTAB 21: PRINT
     "VIEWING WINDOW"
2160  GOTO 430
2200  REM
2201  REM   QUIT COMMAND
2202  REM
2210  IF Q <  >  ASC ("Q") THEN 430
2220  XDRAW 1 AT CL + 1,CT + 3
2230  VTAB 23: PRINT "SURE YOU WANT TO QUIT?"
2240  GOSUB 3500
2250  IF Q <  >  ASC ("Y") THEN  VTAB 22: CALL  - 958: GOTO 410
2260  HOME : POKE  - 16303,0: POKE  - 16298,0: VTAB 24
2270  GOTO 9999
3000  REM
3010  REM   SUBROUTINES
3020  REM
3100  HOME
3110  HTAB 15: PRINT "COMMAND MENU": HTAB 15: PRINT "------- ----"
3120  VTAB 4: PRINT "I,J,K,M"; TAB( 9);"CURSOR MOVEMENT": PRINT : PRINT "P"; TAB
     ( 9);"PLOT POINT AT CURSOR POSITION": PRINT
3130  PRINT "E"; TAB( 9);"ERASE POINT AT CURSOR POSITION": PRINT : PRINT "C"; TA
     B( 9);"CLEAR SCREEN": PRINT
3140  PRINT "T"; TAB( 9);"MAKE SHAPE TABLE": PRINT : PRINT "S"; TAB( 9);"SAVE SH
     APE SOURCE FILE TO DISK": PRINT
3150  PRINT "G"; TAB( 9);"GET SHAPE SOURCE FILE FROM DISK": PRINT : PRINT "H OR
     ?"; TAB( 9);"HELP (RETURN TO THIS MENU)"
3160  PRINT : PRINT "Q"; TAB( 9);"QUIT PROGRAM EXECUTION"
3170  VTAB 24: HTAB 10: PRINT "HIT SPACE TO EXIT MENU";
3180  GOSUB 3500: IF Q <  >  ASC (" ") THEN 3180
3190  VTAB 21: CALL  - 958
3200  RETURN
3300  POKE 230,32: CALL 62450: HGR : SCALE= 1: ROT= 0
3310 PT = YMAX + 1:PB = 0:PL = XMAX + 1:PR = 0
3320  VTAB 21: HTAB 2: PRINT "ACTUAL SIZE";: HTAB 21: PRINT "VIEWING WINDOW";: C
     ALL  - 958: PRINT
3330 X =  INT (XMAX / 2):Y =  INT (YMAX / 2)
3340 MR = ML + XMAX * 4:MB = MT + YMAX * 4
3350 CL = ML + (X - 1) * 4:CT = MT + (Y - 1) * 4
3360  RETURN
3400  HCOLOR= 7
3410  FOR I = ML TO MR STEP 4: HPLOT I,MT TO I,MB: NEXT I
3420  FOR I = MT TO MB STEP 4: HPLOT ML,I TO MR,I: NEXT I
3430  RETURN
3500 Q =  PEEK ( - 16384): IF Q < 128 THEN 3500
3510  POKE  - 16368,0:Q = Q - 128
3520  RETURN
9999  END
```

Text continued from page 303:

tables are named QUOTBL, LOSTRT, and HISTRT. QUOTBL is a lookup table used internally by the subroutine to divide the *x*-coordinate by 7. LOSTRT and HISTRT are each 192 bytes long, and they contain the low- and high-order bytes of the address of the leftmost byte of each *y*-coordinate in page 1 of hi-res screen memory. For plotting on page 2 of the hi-res memory, a hexadecimal 20 should be added to each byte in the table HISTRT. Although I wanted the subroutine to be fully relocatable, I compromised this requirement in favor of additional speed. However, as I have written it, relocating the subroutine requires changing only the two locations referencing QUOTBL in lines 38 and 41 of listing 1.

A Note on Color

One of the most difficult aspects of using the Apple high-resolution graphics mode is trying to control the color of objects displayed on the screen. This difficulty arises because a color cannot be individually assigned to each pixel on the screen; the color depends instead on such factors as whether an object is drawn with pixels horizontally alternating between on and off and whether the on pixels have even or odd *x*-coordinates. Through careful programming and shape-table composition, you can control colors in this manner using the shape subroutine presented in this article. In newer Apples, however, two more colors are added to the hi-res screen by defining the previously unused high-order bit in each word in hi-res screen memory. Unfortunately, these colors cannot be easily displayed using the shape subroutine because the subroutine forces the extra bit in the hi-res screen to 0. For a complete description of color in the Apple hi-res screen, see page 19 of the *Apple II Reference Manual* (Cupertino: Apple Computer Inc., 1979).

The Shape-Editor Program

Although it is not difficult to form the shape table for a given shape, it is often time consuming. When writing a program that uses shapes, you rarely know in advance the exact pixel pattern that makes up the shape. Even if you know the pattern, you're probably not sure whether the shape will look good on the hi-res screen. It might take you hours to develop a suitable shape if you have to write out each trial on graph paper, form the shape table, and use the subroutine to display the shape before you can tell if it is satisfactory. This time-consuming method can bring the creative process to a halt. A more desirable situation would be one in which you could easily experiment with different shapes on the hi-res screen until you were satisfied with the results and then form the shape table directly from the screen image. I had this concept in mind when writing the shape-editor program shown in listing 3. The program features complete hi-res editing, both actual size and a blown-up view of the shape being drawn, disk storage of the current shape (the source file) for future editing, and assembly of a shape table from any portion of the current screen.

The editor program requires an Apple II with 32K bytes of memory, a disk drive, and Applesoft in ROM (read-only memory). When you run the program, the list of commands shown in photo 1 comes up on the screen. After you press the space bar, the left area of the screen becomes blank, and a grid appears on the right. The blank area is the "slate" on which you can draw different shapes actual size. Anything drawn also appears enlarged on the grid, making it easier to see details of the shape. Once the grid has been drawn, a

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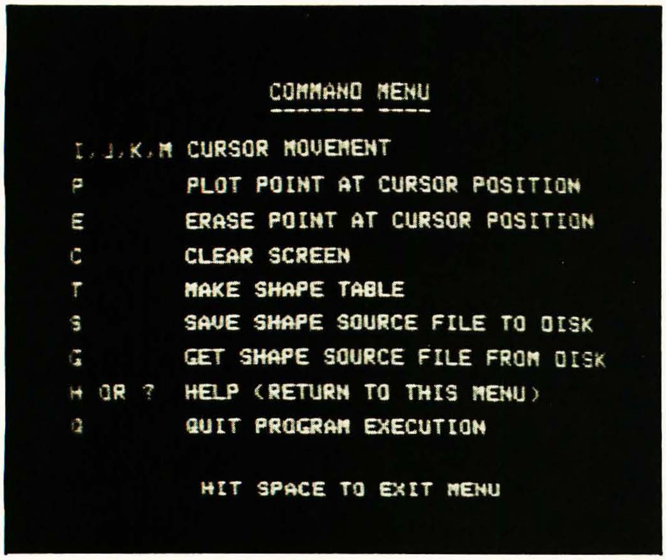


Photo 1: *The command menu that appears at the beginning of the shape-editor program (listing 3). This menu also appears whenever the Help key is pressed.*

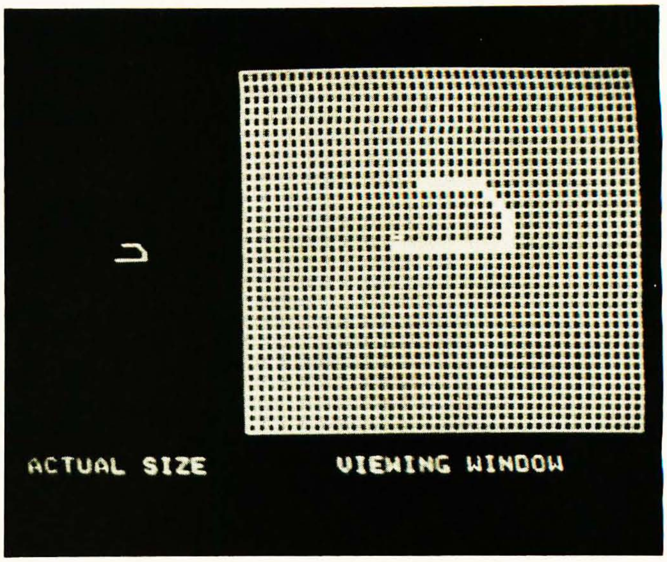
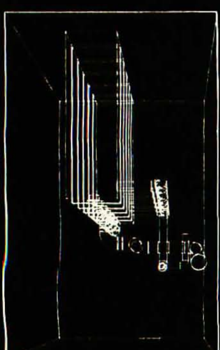


Photo 2: *A view of the screen-edit mode of the shape-editor program. The figure on the grid is an enlarged view of the actual-size shape on the left side of the screen. The cursor is the small horizontal line in a square above the lower left corner of the displayed shape.*

small horizontal line appears in one of the small squares in the grid. This is the cursor, which always shows the current drawing position of the program.

Once the cursor appears on the screen, you can execute any of the commands listed in the menu (photo 1) by pressing the corresponding letter on the keyboard. The letters I, J, K, and M are used for moving the graphics cursor up, left, right, and down, respectively. The Plot command plots a point at the current cursor position, and the Erase command erases the point at the current cursor position. Neither the Plot nor the Erase command causes any harm if the command has already been used at the cursor position (e.g., if the Plot command is used at a position where a point already exists). The Clear command clears the screen after prompting you to verify that the screen should indeed be cleared. By using the cursor-movement, Plot, Erase, and Clear commands, you can draw the desired shape on the screen and modify it as many times as necessary. A shape being drawn in this screen-edit mode is shown in photo 2.

With the Table command, you can make a shape table from any segment of the screen where you have drawn a shape. After choosing the Table command by pressing the T key, you must choose the smallest rectangle that encloses the shape; this is the same rectangle chosen when forming the shape table manually as previously described. You specify the boundaries of this rectangle by moving the cursor to the upper left position of the rectangle and pressing the Return key and then doing the same for the lower right corner of the rectangle. The corners are inclusive; that is, the rows and columns that contain the corners become the outermost edges included in the shape table. A portion of the rectangle selection process is shown in photo 3. After you select the desired rectangle, the program will form the shape table. The time this takes (typically 15 to 30 seconds) depends on the size of the shape. The completed shape table is displayed on the screen in either decimal or hexadecimal form, de-



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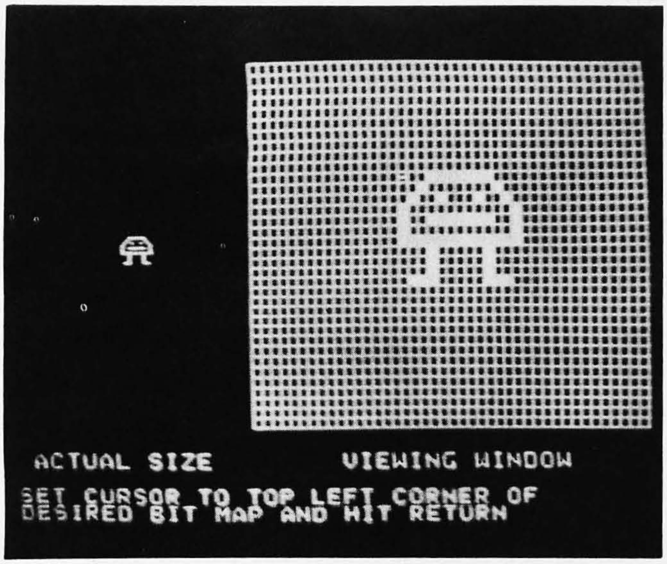

Photo 3: *A view of the first step in forming a shape table. The desired shape is selected by defining a rectangle enclosing the shape. Here, the user has positioned the cursor to the correct position to define the upper left corner of the rectangle.*

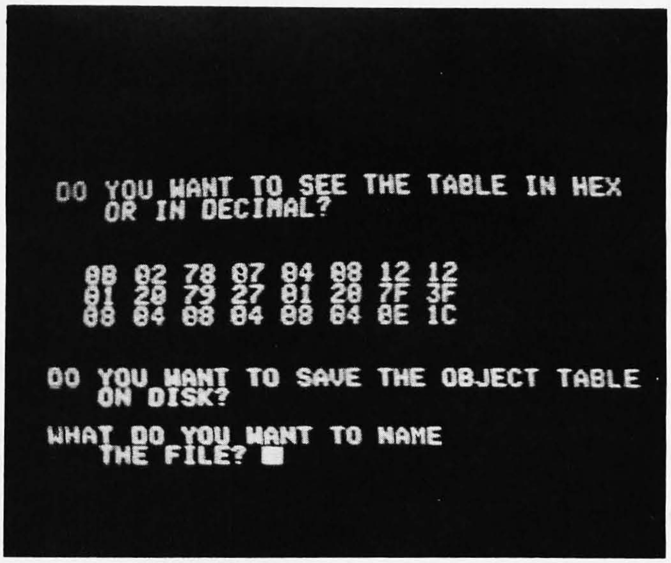

Photo 4: *A view of the screen after the shape-editor program has formed the shape table for the shape shown in photo 3.*

pending on how you answer a prompt. The program will then save this object-file shape table on disk as a standard binary file if you so desire. You are then asked whether to return to the screen-edit mode or end the program. Photo 4 shows the final shape table formed from the sample shape used in photo 3.

The Save and Get commands let you store on disk and later retrieve any picture drawn in the screen-edit mode. The Save command prompts you for a file name and then saves to disk a representation of the shape drawn on the grid. The Get command can then be used to retrieve and display the picture as long as the saved file remains on disk. Because the Get command erases any drawing previously on the screen, you are first asked to confirm that a file is to be loaded. Once the picture is retrieved, it can be modified or assembled into a shape table just as if the picture had been entered using the keyboard commands.

The Help command (executed by pressing the H or ? key) returns you from the screen-edit mode to the menu shown at the beginning of the program for a quick command-letter check. Pressing the space bar returns you to screen-edit mode with the contents of the screen unaltered. The Quit command ends the program. Because any drawing on the screen is lost once the program is ended, you are asked to confirm the Quit directive.

Summing Up

Using the techniques and programs described in this article, you can implement professional-looking animation on the Apple without having to work around the limitations of the standard Apple shape subroutine. Although I wrote my shape subroutine with animation in mind, the subroutine is useful in any graphics applications where detailed shapes must be drawn. Using the graphics editor as a development tool, virtually any shape can be easily displayed on the hi-res screen.■

Richard T. Simoni Jr. (29 Farnham Park Dr., Houston, TX 77024) is currently enrolled as a senior electrical engineering/computer science/math science major at Rice University in Houston, Texas.

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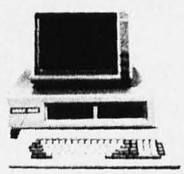

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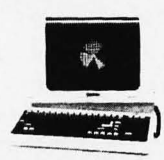

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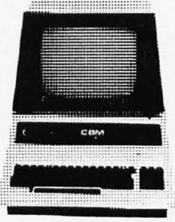

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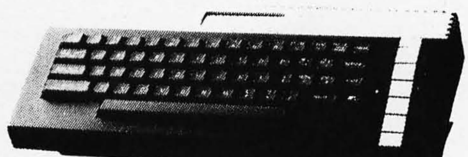

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The Debate Goes On . . .

A discussion of the future of microcomputer languages

by Jerry Pournelle

I've written several large computer programs. The two largest, an accounting package and my minimum database do-all program, were originally written in BASIC. Another large program, my interstellar trader game, was written in Pascal. Recently I've had to make extensive revisions in all three—with interesting results.

First, I find it impossible to work with BASIC programs. My accounting package, although originally in BASIC, was long ago translated to CBASIC and from that to CB-80 (also called Compiled CBASIC). The translations make it possible to maintain the programs. If that hadn't been done, I wouldn't even try.

Example: my accounting program doesn't do depreciation, because almost all my accounting is done to satisfy the IRS, and the IRS wants depreciation handled in a rather special way. When I first began using microcomputers to keep my books, I wrote what I thought was a simple BASIC program to keep track of depreciation. It didn't have to do much: simply list the item, when it was bought, the useful life, purchase price, amount claimed this year, and cumulative amount claimed over the life of the item. Each year I add new items at the end of the list, then run the program to figure and list out depreciated items.

The program has some checking to do, of course; the last year's claimed amount can't make the cumulative amount claimed be larger than the purchase price. Also, if the item was purchased *this* year, you can't claim a full year's depreciation, and have to prorate it by the number of months you've used the equipment. Even so, it's a simple program.

It's simple, but this year it took me about as long to update that simple-minded little BASIC program as it did to add major new features to the accounting package. When I get a chance, I'm going to scrap my depreciation program and write it over, probably in CB-80 because it has to handle files, and I've still got some problems doing file handling with CP/M Pascal.

What I'm not going to do is put up with normal BASIC programs, with their line numbers, cramped printout format, and the primitive text-editing capabilities.

With CB-80 it's possible to write structured programs. Moreover, the compiler can be used to catch a lot of bugs. Example: my minimum database has a procedure to check the size of any entry. This is useful, because entries that are too long can't be printed properly (especially if they're to be printed on a mailing label). The original program got its input by calling a subroutine that both input the data and checked the input length.

Alas, that's silly. If you forget to specify the input length before calling the input subroutine, then the input length is checked against what the program was *last* told the input length should be; and that can cause really boffo problems. I know, because I did forget, not once but several times.

The remedy was simple: use a *function* to get input and check

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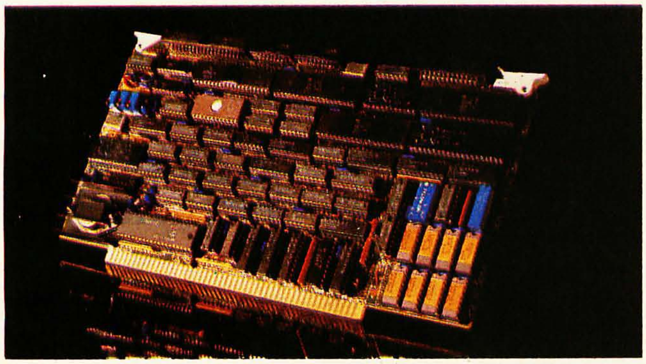

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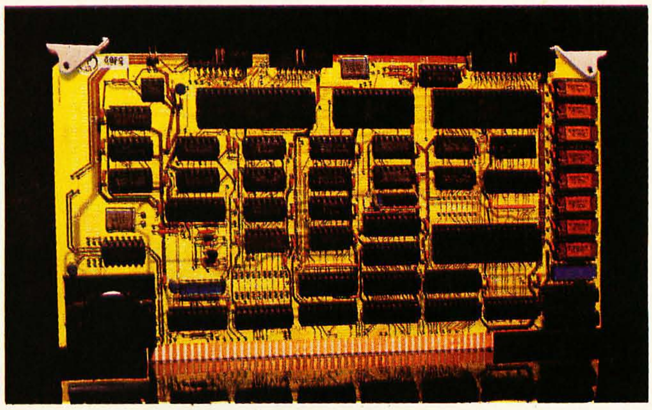

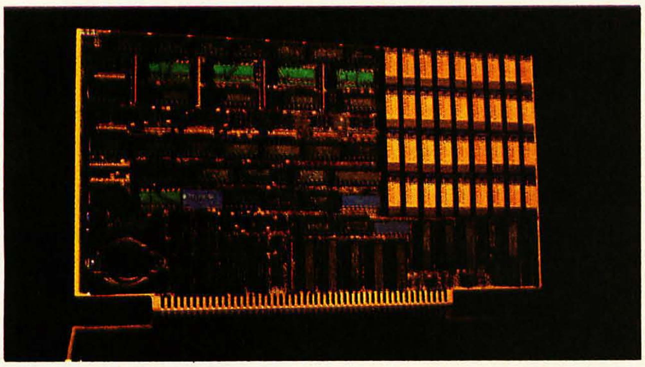

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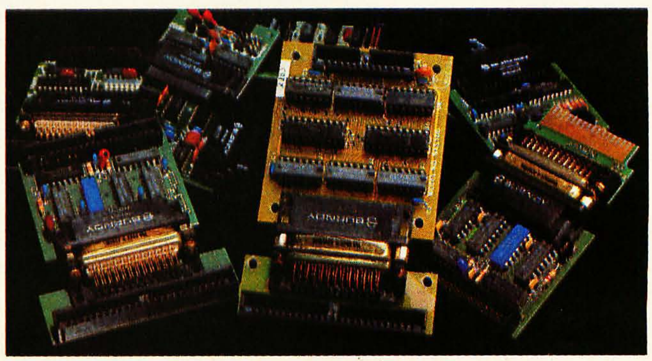

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length. Define the function so that you *must* give it a maximum input length as a parameter when you call it. Now if you forget to do that, the compiler will complain.

When I did this, it came to me with blazing clarity that I'd hit on a major secret of good programming practice: let the compiler do much of the work for you. CB-80 is well designed to let you write structured code with good error checking.

However: it doesn't *force* you to write good code. You can still do things the wrong way if you want to. Pascal doesn't force you to write good code either, but it tries harder than CB-80. Marvin Minsky (cofounder of the MIT Artificial Intelligence Laboratory) once said that Pascal was a voluntarily worn straitjacket. In some ways he's right: one uses Pascal precisely because it won't let you do certain things. This can be annoying when you're writing the program, but it's surely a blessing when, later on, you haul it out and try to remember what you did.

With that for background, let's speculate on the future of computer languages.

Viable Languages

I used to worry about conducting language discussions, because probably half my readers don't write programs. However, the mail indicates that even those who don't write programs find the subject interesting. It is, after all, a matter of some importance: what languages will prevail in the microcomputer field?

No one knows. I have some informed guesses, and I get a lot of feedback from both amateur and expert readers; but I've lost the operator's manual to my crystal ball, so my predictions aren't 100 percent reliable. For all that, the subject is too important to ignore, and every now and then it's valuable to review just where things are in the field.

Let's set a ground rule. It's obvious that microcomputers will continue to grow in capability even as their prices fall. The distinction between *micro*computer and minicomputer is already blurred. In the next few years, memory will continue to drop in price while system speeds increase; within two years, one will be able to buy the equivalent of a VAX—the top-of-the-line minicomputer from Digital Equipment Corporation—for $6000 or so, what people now pay for a good microcomputer. This future "microcomputer" will run at 12 to 15 MHz and have a half-million to a million bytes of memory; in other words, the microcomputer will in effect have the power of machines that people now pay $75,000 and up for.

What languages will programs for the new generation of "microcomputers" be written in?

The first thing to note is that "efficiency" of the language isn't very important. There's enough computing power and memory to make up. True, languages that are *really* slow, or waste great gobs of memory, aren't likely to become popular; but cheeseparing benchmark comparisons won't matter a lot.

Given that, let's look at the candidate languages.

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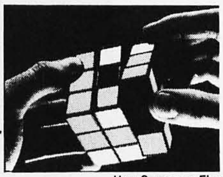

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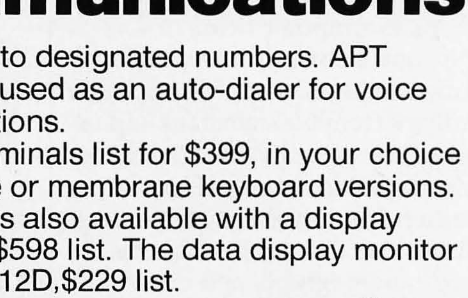

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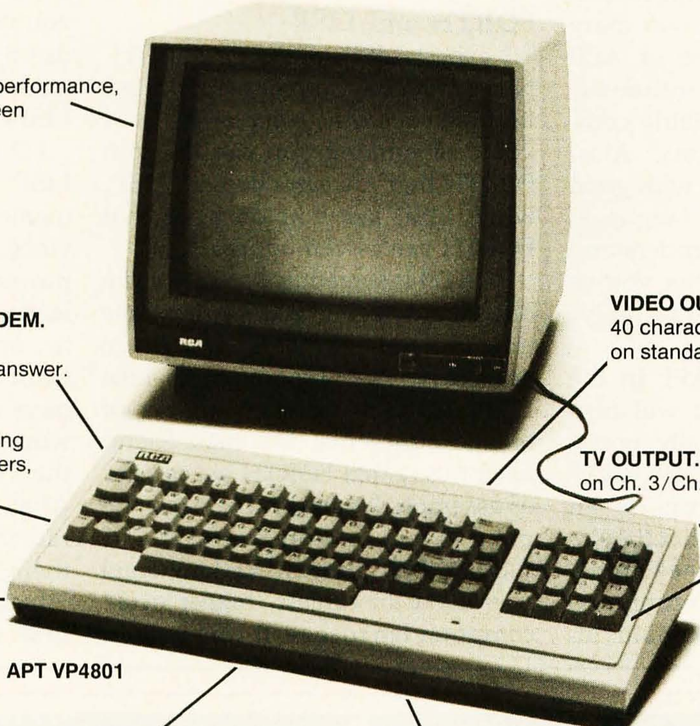

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APL

APL, for those who don't know, is an interpreted language (like LISP or BASIC). It makes use of many curious symbols, such as squashed squares and bent arrows. It is very powerful. You can multiply matrices with a single command, invert them with another, and do transformations of the results with two more commands. A single line of APL code can do complex arithmetic, logs, trigonometry, and fairly complicated logical operations. Alas, APL has been described, with good reason, as a "write only" language: you're just not likely to understand your program an hour after you've written it. Used interactively, though, it's hard to beat.

I foresee a place for APL in the microcomputer future: it will turn small computers, especially portables, into *very* powerful desk calculators. It will already run on an Osborne 1, I understand that they're working on a version for the Otrona, and I expect that trend to continue. If someone will write a good introductory text, and APL implementers will do good tutorials with lots of examples, it's possible that APL will become quite popular for quick-and-dirty problem solving. It won't ever be as popular as BASIC for calculator-like computation, but it will contend with it.

FORTH and LISP

I expect LISP to absorb FORTH. Not completely, of course, because nothing ever wins completely; but I know of nothing you can do with FORTH that you can't do with LISP, while LISP lets you do a lot that FORTH can't even approach.

FORTH is sometimes used to write operating systems, and was for some time the only powerful language available to Atari programmers. Like LISP, FORTH boasts a number of fanatic adherents. My mad friend used to say that FORTH was a kind of assembly language that used the programmer as a preprocessor.

LISP (LISt Processing language) was one of the earliest "higher level" computer languages. It was written by John McCarthy in the 50s and has dominated the artificial intelligence field ever since. It's a very strange language, using peculiar notation and *lots* of parentheses; but it's very powerful.

The main problems with LISP are (1) it's hard to learn from books, although not so hard to learn if you've access to people who already use it, and (2) it uses memory like mad, so that there haven't been good LISPs for microcomputers.

FORTH has some similarities to LISP but doesn't use as much memory. People I respect have convinced me that LISP is much more powerful than FORTH. Having half learned both LISP and FORTH, it's my opinion that they're equally difficult to master; both require a good bit of concentration, and you have to work until something clicks—what the Gestalt psychologists call "the Aha! experience." They're also rather easy to forget if you don't use them regularly.

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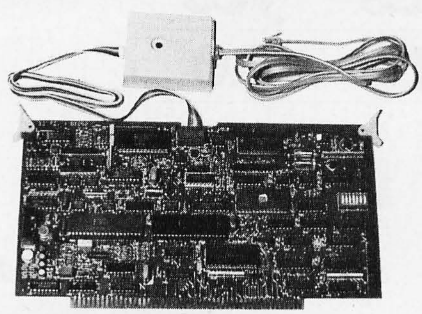

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vestment should get Daniel P. Friedman's *The Little LISPer.* This rather odd book "is a programmed text based on lecture notes from a two-week 'quickie' introduction to LISP for students with no previous programming experience and an admitted dislike for anything quantitative." It has to be experienced to be appreciated; I found myself alternately fascinated and throwing the book across the room. It certainly shows—not tells, but shows—you a lot about LISP.

As memory gets cheaper, small computers get more powerful, and communications get simpler, I expect many publishers will offer better LISP interpreters (and compilers; LISP is a hybrid, with the possibility of both interactive-interpretive mode and compiled mode), as well as more online tutorials, so that LISP will be easier to learn. FORTH and LISP users both tend to be fanatics. I'm neither, so it's only an informed guess, but I suspect that as LISPs get more common, LISP will get the bulk of the recruits who would otherwise have gone to FORTH.

COBOL and FORTRAN

Every time I say anything negative about COBOL, I get half a dozen letters reminding me that there are many *billions* of dollars' worth of COBOL programs. Surely those won't go away?

I think they will. Not instantly, and I doubt that COBOL will vanish entirely, but I do not see a large place for COBOL in the microcomputer world. If it were going to catch on, it would have by now; and it just hasn't. That, in my judgment, is just as well. COBOL is a language whose time has passed. It doesn't force readable code, it takes experts to maintain large COBOL programs, and it doesn't have most of the features required for structured programming.

It does do certain things well. COBOL has built-in commands for sorts and merges and other fairly complex operations. On the other hand, it's not hard to translate well-written COBOL programs into some other language, such as Pascal, while

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those programs not easily translated are generally almost impossible to maintain. For that matter, you can call some of those splendiferous special routines, such as Sort, from inside languages like Modula-2 . . .

FORTRAN is another language that won't go away entirely, but will, I think, fade into the background. For a while it looked as if FORTRAN, augmented by the RATFOR (RATional FORtran) preprocessor, might stake out a large place in microcomputerland, but that didn't happen.

FORTRAN, which is very useful for crunching lots of numbers, is not all that well designed for anything else. You can write complex text-oriented programs in FORTRAN; the original Crowther and Wood Adventure of the Colossal Cave was written in FORTRAN. It wasn't designed for that, though, and FORTRAN programmers usually must resort to tricks to make it handle text well.

Because so very many COBOL and FORTRAN programs are in existence, neither language will die; but as time goes on, most of those programs will be translated into other languages with better structural features, while fewer and fewer programmers will use either language for writing new programs for microcomputers.

PL/I

The PL/I programming language is very popular among mainframe and large minicomputer programmers. It was one of the earliest of the "higher level" languages and one of the first designed to allow formal structuring. It has good string handling, relatively good portability, and better input/output and file handling than Pascal.

In fact, considered a feature at a time, PL/I sounds nearly ideal. My late mad friend found it so attractive that he wrote nearly all his programs in it.

There is a good implementation of PL/I for CP/M microcomputers; what's more, it's not likely to go away. Dr. Gary Kildall, president of Digital Research and author of CP/M, is a PL/I enthusiast. Much of the original CP/M was written in a subset of PL/I. Kildall has committed Digital Research to provide PL/I for all CP/M upgrades; this presumably includes new systems based on the 68000 and 8086 chips.

Despite these advantages, PL/I hasn't caught on in the microcomputer world. Joan K. Hughes wrote one of the standard PL/I textbooks (*PL/I Structured Programming*) but wrote all the programs for her microcomputer consulting firm in CBASIC because PL/I was not then available for CP/M microcomputer systems; later, she found that she had too much invested in CBASIC programs to change over.

Then, too, many computer users—including myself—do not find PL/I programs readable, nor is the language easily learned. "Easily" is, of course, a relative term; PL/I is not much harder to learn than, say, FORTRAN. It has many more statements than Pascal, but PL/I programmers find that a desirable feature.

Like CB-80, PL/I requires separate compile and link operations, but

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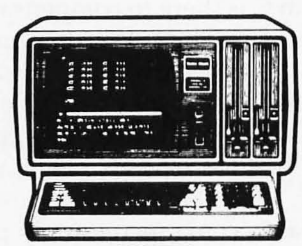

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both are relatively straightforward. When PL/I first came out, the only manuals were written in the early Digital Research style of high density and low readability, while CBASIC had remarkably clear documentation. This may have contributed to CBASIC's early ascendancy.

The newest Digital Research PL/I manuals have been completely rewritten. They are clear, readable, and filled with examples. A lot of minicomputer programmers are quite familiar with PL/I. Therefore, now that the distinction between micro and mini is becoming blurred, it's possible that PL/I, despite its relatively late start, will experience rapid new gains in popularity. The language certainly can't be counted out.

The C Programming Language

The "C" language was developed at Bell Laboratories. Until recently its fate was intimately dependent on the future of the Unix operating system. In the past couple of years, though, CP/M versions of C have appeared. One, Leor Zolman's BDS C Compiler, almost single-handedly made C a formidable contender because many useful programs were written in it.

BDS C had severe limits; now lots of C compilers without those limits are available. In addition, CP/M-68K, the CP/M operating system for machines using the 16-bit 68000 processor chip, comes with a limited C compiler. This will undoubtedly stimulate new users to learn something of the C language.

C is popular, and both C and the Unix operating system have fanatical supporters. The language is powerful and is certainly easier to learn than assembly language.

The drawback is readability. C programs are not self-documenting; one could argue that there ought to be at least one comment for each line of code. Alas, the programs are *almost* readable, and while one is writing C programs the purpose of each line is quite clear, so that further comments seem silly and are often omitted. Six weeks later the program is nearly incomprehensible.

A second problem with C—at least with the compilers I have been able to work with—is that it generates *very* large programs. For example:

```
/* A Very Simple Program. */
main ( )
{ printf("This is a very simple
  program. \ n");
}
```

is a program that merely prints the quoted message. (The \n specifies a "newline," i.e., carriage return and linefeed.)

We compiled it with Lattice C, which is a well-regarded C compiler. The program itself is 384 bytes long. It compiles into 178 bytes of object code. It must be linked to turn it into a command file before it can be run. That produces a program 11,008 bytes long. This seems excessive.

When we installed our M-Drive (a "silicon disk" program that deludes the computer into believing that extra memory is a *very* fast disk drive), we required a program to format the "memory disk." The program furnished us by Compupro was written in Whitesmiths C and was 16K bytes long. Tony Pietsch found this absurd and wrote a format program in assembly language: it was only 487 bytes long.

There are good reasons for this obesity. The C language was originally intended for use with the Unix operating system, and much of the seemingly excessive code that must be packed into programs compiled in C is there to compensate for the missing Unix. We may understand this and still be unhappy at the code size. There may be implementations that don't generate superfat code, but we haven't come across one.

C has become increasingly popular—with fanatic supporters. It will certainly survive. However, I don't expect it ever to become a highly popular language, and if I had to bet on its future, I'd say that it will take a respectable niche, after which its growth will be quite slow in comparison to the microcomputer world in general.

Until recently, those interested in learning more about the C language pretty well had to read *The C Programming Language* by Brian Kernighan and Dennis Ritchie. This book is better written than many computer texts, but it isn't easy reading, and it was never intended for microcomputer users.

I have recently received *C Programming Guide* by Jack Purdum. I found this much clearer than Kernighan and Ritchie. Purdum's book has plenty of illustrative examples and even compares C programs with similar programs in BASIC. It recognizes that many readers will be using CP/M systems and explains some of the problems they may encounter. There's a very good discussion of pointers; this is especially welcome because C makes extensive use of pointers. I recommend this book to anyone interested in learning more about the C language. Read it *before* trying to tackle Kernighan and Ritchie.

I have a large number of C compilers and hope to do an extensive comparison of them for a future issue.

Pascal and Modula-2

Pascal has been the real success story in microcomputing. Last year more books were published about Pascal than about BASIC. (By books, I mean titles; there were probably more copies sold of BASIC books than Pascal books.)

The Pascal language was devised by Prof. Niklaus Wirth of Zurich. It was originally intended as a teaching language that would force students to write readable, structured programs, and thus train them to think about programming in a logical way. It generated a number of enthusiastic converts who developed Pascal into a practical language. The structured features caused many program bugs to be caught by the compiler, so that once a program written in Pascal is made to run, it often runs properly without much debugging.

Pascal is now taught in many universities. Some even require Pascal proficiency for graduation in any science. Pascal courses are found in high schools, and that practice is also spreading. Thus the language

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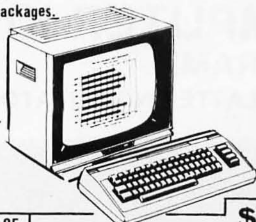

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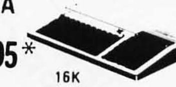

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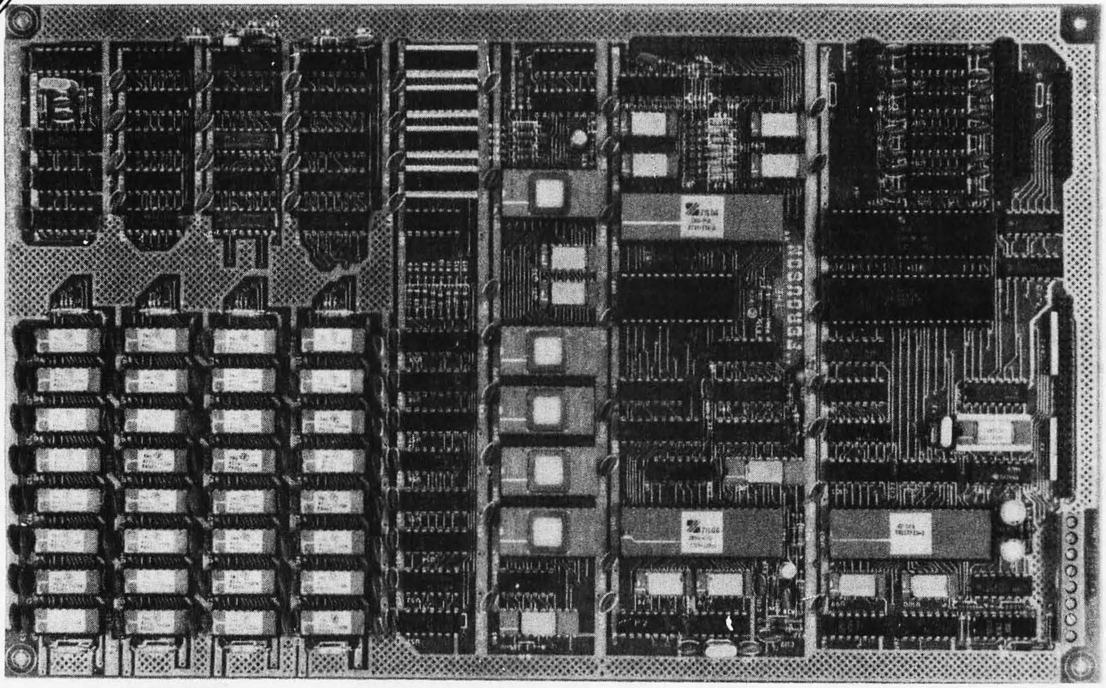

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has a secure place and is probably second only to BASIC in popularity among microcomputer users.

Pascal does have some very severe drawbacks, particularly as implemented for small computers. The original language had primitive (and not well-designed) input/output structures, so that most I/O has to be done through *extensions* to the language. The extensions have not been standardized, which compromises portability. (Portability refers to the ease of getting programs that run on one kind of machine to run on any other.) The language also has internal limits. Many of them have been discussed at length in previous columns.

Most of Pascal's deficiencies have been corrected in Niklaus Wirth's newest language, called Modula-2. As I write this, we don't have many implementations of Modula-2; but the two potential U.S. publishers of Modula-2 for microcomputers, Volition Systems of San Diego and Logitech of Palo Alto, promise new compilers Real Soon Now. Fortunately, the two companies are in communication and seem willing to agree on standard ways of extending Modula-2. They may set a de facto standard that newer publishers will have to meet, and thus avoid the cacophony of dialects that afflicts Pascal.

My experience has been that Pascal programmers tend to become Modula-2 enthusiasts. Much of the excitement and popularity of Pascal may thus be transferred to Modula-2. There are good reasons for this. Modula-2 is more powerful than Pascal and a lot easier to use. It is also very easy to translate Pascal programs into Modula-2; 90 percent or more of the work can be done by a translator program written in Modula-2. Add that Modula-2 is suitable for writing systems programs—I've seen a very powerful operating system written in Modula-2—and it's not hard to predict that Modula-2 will become increasingly more popular as it becomes available.

My own prediction is that Modula-2 will swallow a good chunk of both Pascal and C. So far not many experts join me in that fore-

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Books Cited

C Programming Guide $17.95
Jack Purdum. Indianapolis: Que Corporation, 1983, 250 pages, software.

The Little LISPer $3.95
Daniel P. Friedman. Palo Alto, CA: Science Research Associates, 1974, 64 pages, softcover.

cast, but I've seen nothing to make me change my views on the matter.

Ada

The Department of Defense estimated that if all DOD programs were written in a single language, the resulting savings would run to billions of dollars. After long consideration by a number of middle- and high-level committees, Ada was created to be *the* DOD programming language.

Ada will certainly have a large place in the computer world; any language supported by the Department of Defense would have to. As I've said before, learning to program in Ada is surefire job insurance.

Ada was designed by a committee, and it shows: it has *tons* of bells, whistles, features, and gimmicks. This tends to complicate the language, and some computer science experts have professed concern: given the complexity of Ada, how can you verify the language? That is: can you be sure the compiler is doing all—and only—what you think it will, or can there be mysterious unintended side effects? If one side effect is to launch a missile without permission, all the savings resulting from Ada's creation could literally go up in smoke.

It's very hard to estimate Ada's future in the microcomputer world. No full Ada compilers for microcomputers are yet available, and this situation isn't likely to change for a while. I think Ada's future in microcomputerland depends in large part on just how quickly we get an Ada compiler we can use.

Incidentally, I have just received Augusta, a program that compiles a subset of Ada on the Z80. It has only just come, so I have been unable to compare it with Janus (the other Ada-subset compiler for microcomputer systems). Augusta seems to run, and the manual is written in clear English with numerous examples. It does not support packages, multitasking, real numbers, enumerated types, user-defined types and records, or exception error handling. I find the Janus documentation more complete and better organized, but this is impressionistic, not based on detailed objective comparison.

Bottom Line

If I had to pick a single language for future microcomputers, it would be Modula-2. That, however, is based on certain expectations about future Modula-2 implementations; just now (May Day 1983) I have no Modula-2 for CP/M systems.

If I were going to buy and learn one single language of those available today, I'd be hard put to choose. The two I'd consider would be CB-80 and Pascal MT+ with the Speed Programming Package. Both Pascal MT+ and CB-80 are expensive; the term "overpriced" is a value judgment I find myself tempted to use. Even so, I like Pascal MT+ somewhat better than I do the other Pascal implementations I have.

Deciding between Pascal and CB-80 isn't easy. Pascal, which also serves as a good introduction to Modula-2, is probably the more valuable to have learned over the long haul; but I find just now that I use CB-80 (and CB-86) more than I use Pascal.

It may be, of course, that I've missed the real contender; that Logo, Smalltalk, or some such will sweep the field. I don't think that will happen, but it isn't impossible.

The language debate will continue.■

Jerry Pournelle welcomes readers' comments and opinions. Send a self-addressed envelope to Jerry Pournelle, c/o BYTE Publications, POB 372, Hancock, NH 03449. Please put your address on the letter as well as on the envelope. Due to the high volume of letters, Jerry cannot guarantee a personal reply.

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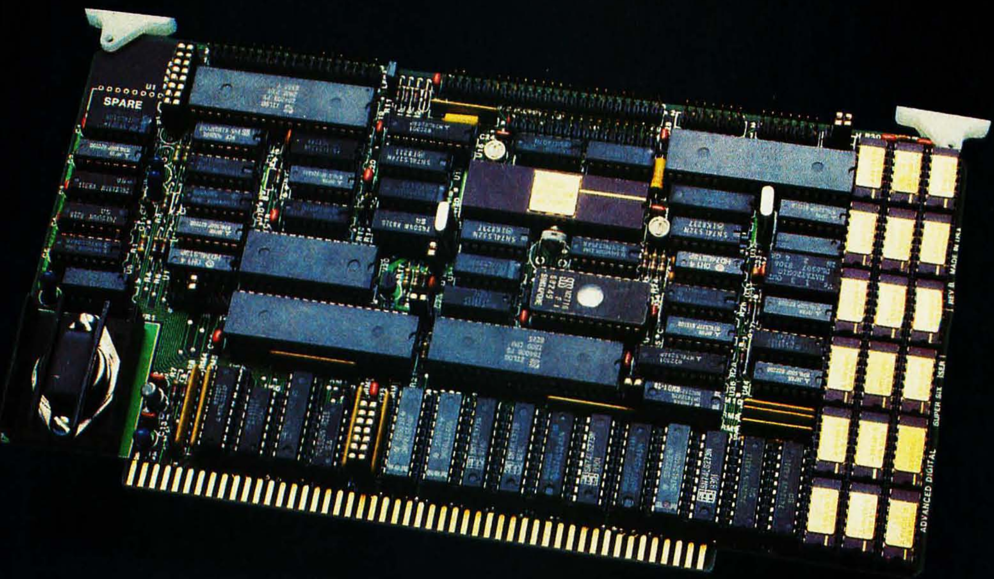

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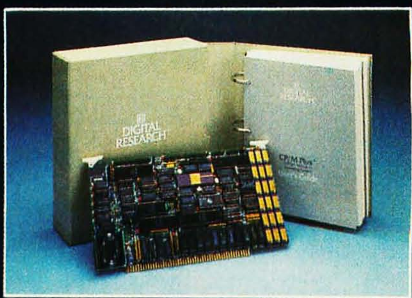

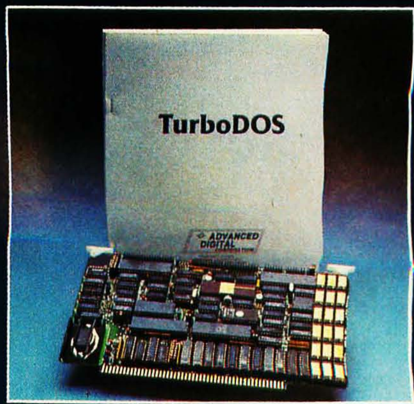

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The IBM PC and the Intel 8087 Coprocessor

Part 1: Overview and Floating-Point Assembly-Language Support

Addition of the 8087 chip to the IBM PC provides instant access to powerful floating-point, integer, and BCD arithmetic operations from assembly language

by Tim Field

The Intel 8087 Numeric Data Processor (NDP) is a coprocessor chip that greatly extends the calculation abilities of the Intel 8088 CPU (and Intel CPUs like the 8086, 80186, and 80286). The 8087, when attached to the 8088, performs a useful range of operations on a variety of data types much faster, more accurately, and with less trouble.

[**Editor's Note:** *The acronym CPU, which stands for central processing unit, is one that we usually do not use in BYTE because, for most material in the magazine, the word is more accurately replaced by the word "microprocessor." In this situation, however, the 8088 microprocessor is the central processing unit in relation to the 8087 Numeric Data Processor. Because of this, we will use the acronym CPU to refer to the 8088 and NDP to refer to the 8087. . . .***G. W.**]

The IBM Personal Computer uses an Intel 8088 CPU and has an empty 40-pin socket just waiting for an 8087. With the 8087 NDP in place, you can immediately access it with software that explicitly issues the proper instructions to the 8087.

A great deal of confusion abounds concerning the level of support that IBM software currently provides for the 8087-enhanced PC. At one meeting of an IBM users club, a user said he had purchased an 8087, plugged it into the socket, and could not tell any difference in the execution speed of his BASIC programs. He was quite confused why the PC did not take immediate advantage of the new resource.

Unfortunately, things just are not that easy. As I write this article, the only high-level support of the 8087 in IBM software is in the new APL package. Pascal, BASIC, and the other IBM languages will not automatically execute using the 8087. IBM designed the hardware into the IBM PC and the IBM PC XT, but it is only beginning to support it officially.

For the moment, we must create our own software utility to make use of the 8087 in the IBM PC. This month, we will look at a piece of software called M8087 that makes it easy for the assembly-language programmer to add 8087 instructions to programs. Next month, we will use this assembly-language support to provide higher-level software support for the IBM Pascal Compiler.

While this article specifically discusses the 8087 interface with the IBM Personal Computer, the topics under

Processor Control Instructions

FINIT/FNINIT	Initialize processor
FDISI/FNDISI	Disable interrupts
FENI/FNENI	Enable interrupts
FLDCW	Load control word
FSTCW/FNSTCW	Store control word
FSTSW/FNSTSW	Store status word
FCLEX/FNCLEX	Clear exceptions
FSTENV/FNSTENV	Store environment
FLDENV	Load environment
FSAVE/FNSAVE	Save state
FRSTOR	Restore state
FINCSTP	Increment stack pointer
FDECSTP	Decrement stack pointer
FFREE	Free register
FNOP	No operation
FWAIT	CPU wait

Constant Load Instructions

FLDZ	Load +0.0
FLD1	Load +1.0
FLDPI	Load π
FLDL2T	Load $\log_2 10$
FLDL2E	Load $\log_2 e$
FLDLG2	Load $\log_{10} 2$
FLDLN2	Load $\log_e 2$

Transcendental Instructions

FPTAN	Partial tangent
FPATAN	Partial arctangent
F2XM1	$2^X - 1$
FYL2X	$Y \cdot \log_2 X$
FYL2XP1	$Y \cdot \log_2 (X+1)$

Comparison Instructions

FCOM	Compare real
FCOMP	Compare real and pop
FCOMPP	Compare real and pop twice
FICOM	Integer compare
FICOMP	Integer compare and pop
FTST	Test
FXAM	Examine

Data Transfer Instructions

Real Transfers

FLD	Load real
FST	Store real
FSTP	Store real and pop
FXCH	Exchange registers

Integer

FILD	Integer load
FIST	Integer store
FISTP	Integer store and pop

Packed Decimal Transfers

FBLD	Packed decimal (BCD) load
FBSTP	Packed decimal (BCD) store and pop

Arithmetic Instructions

Addition

FADD	Add real
FADDP	Add real and pop
FIADD	Integer add

Subtraction

FSUB	Subtract real
FSUBP	Subtract real and pop
FISUB	Integer subtract
FSUBR	Subtract real reversed
FSUBRP	Subtract real reversed and pop
FISUBR	Integer subtract reversed

Multiplication

FMUL	Multiply real
FMULP	Multiply real and pop
FIMUL	Integer multiply

Division

FDIV	Divide real
FDIVP	Divide real and pop
FIDIV	Integer divide
FDIVR	Divide real reversed
FDIVRP	Divide real reversed and pop
FIDIVR	Integer divide reversed

Other Operations

FSQRT	Square root
FSCALE	Scale
FPREM	Partial remainder
FRNDINT	Round to integer
FXTRACT	Extract exponent and significand
FABS	Absolute value
FCHS	Change sign

Table 1: *The 8087 instruction set grouped by class.*

consideration should apply fully to almost any 8088- or 8086-based system that has the 40-pin 8087 socket on the system board. If the system runs PC-DOS (or, equivalently, MS-DOS), then the software support presented in this article should be applicable to any user of Microsoft's Macro Assembler for the 8088/8086 systems.

M8087.MAC

The 8087 watches for ESC (escape) instructions as potential operations for it to work on, while the 8088 CPU ignores them. Therefore it is possible for the assembly-language programmer to use the 8087 by looking up the proper escape-code sequence for each 8087 instruction in a table and inserting the ESC instruction in the program. (For example, an FDIV instruction translates to the hexadecimal sequence "DC F1", which translates to "ESC 26H,CX".) Obviously this tedious and error-prone task is the same as assembling the instructions into machine code by hand.

To avoid those errors and save time, we'll let the user

Text continued on page 350

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*3Com Corp. in March *Systems & Software*, pg. 118
**3Com Corp. in March *Systems & Software*, pg. 119

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Listing 1: *The M8087.MAC program. This listing is a collection of macros (written in the IBM Macro Assembler format) that implement the standard Intel mnemonics for the instructions executed by the Intel 8087 Numeric Data Processor. This file lets you write assembly-language programs that intermix 8088 and 8087 instructions.*

```
;*******************************************************************;
;                                                                   ;
;       M8087.MAC - File of macros which provide assembly level     ;
;                   software support for use of 8087 NDP with       ;
;                   the IBM personal computer                       ;
;                                                                   ;
;*******************************************************************;


if1     ; do not include this file in any output listing


;*******************************************************************;
;                                                                   ;
;       ESC_REG - "REG" parameter specifies ESC value.  Issue       ;
;                 proper ESC sequence depending on REG value.       ;
;                 PARAM is a 6-bit parameter whose upper 3-bits     ;
;                 make up the "xxx" bits in the ESC opcode (11011xxx)  ;
;                 and lower 3-bits make up "yyy" bits in source     ;
;                 byte following (using standard "mod" and "r/m"   ;
;                 designators define byte as "modyyyr/m").          ;
;                                                                   ;
;*******************************************************************;

ESC_REG macro PARAM,REG
        ;
        ; We need to determine what "reg" field assignment corresponds with
        ; the current value of REG.  This is used as the source for the
        ; ESC operation.  PARAM is used directly in the ESC call
        ;
        ife REG ; Decrement until REG = Ø, then issue ESC sequence
          ESC PARAM,AX          ; AX = ØØØb (see operand summary for 8Ø88)
        else
          REG = REG - 1
          ife REG
            ESC PARAM,CX                ; CX = ØØ1b
          else
            REG = REG - 1
            ife REG
              ESC PARAM,DX              ; DX = Ø1Øb
            else
              REG = REG - 1
              ife REG
                ESC PARAM,BX            ; BX = Ø11b
              else
                REG = REG - 1
                ife REG
                  ESC PARAM,SP          ; SP = 1ØØb
                else
                  REG = REG - 1
                  ife REG
                    ESC PARAM,BP        ; BP = 1Ø1b
                  else
                    REG = REG - 1
                    ife REG
                      ESC PARAM,SI      ; SI = 11Øb
                    else                ; If REG >= 7, assume 7
                      ESC PARAM,DI      ; DI = 111b
                    endif
                  endif
                endif
              endif
            endif
          endif
endm    ; Done with ESC_REG macro

;*******************************************************************;
;                                                                   ;
;       CHECK_ST - Inputs parameter "ST(i)" and returns with REG=i  ;
;                                                                   ;
;*******************************************************************;

CHECK_ST macro P_ST
        REG = -1            ; Assume no match is found
        ifidn <&P_ST>,<ST(Ø)>    ; Is i=Ø?
          REG = Ø
        endif
        ifidn <&P_ST>,<ST(1)>
          REG = 1
        endif
        ifidn <&P_ST>,<ST(2)>
          REG = 2
        endif
        ifidn <&P_ST>,<ST(3)>
          REG = 3
        endif
        ifidn <&P_ST>,<ST(4)>
          REG = 4
        endif
        ifidn <&P_ST>,<ST(5)>
          REG = 5
        endif
        ifidn <&P_ST>,<ST(6)>
          REG = 6
        endif
        ifidn <&P_ST>,<ST(7)>
          REG = 7
        endif
        ifidn <&P_ST>,<st(Ø)>    ; Is i=Ø?
          REG = Ø
        endif
        ifidn <&P_ST>,<st(1)>
          REG = 1
        endif
        ifidn <&P_ST>,<st(2)>
          REG = 2
        endif
        ifidn <&P_ST>,<st(3)>
          REG = 3
        endif
        ifidn <&P_ST>,<st(4)>
          REG = 4
        endif
        ifidn <&P_ST>,<st(5)>
          REG = 5
        endif
        ifidn <&P_ST>,<st(6)>
          REG = 6
        endif
        ifidn <&P_ST>,<st(7)>
          REG = 7
        endif
        ;
        ; If i not between Ø or 7, see if actually an
        ; "ST(i)" or "ST(I)" string, indicating use of
        ; top of stack element
        ;
        ifidn <&P_ST>,<ST(i)>
          REG = Ø
        endif
        ifidn <&P_ST>,<ST(I)>
          REG = Ø
```

Listing 1 continued on page 339

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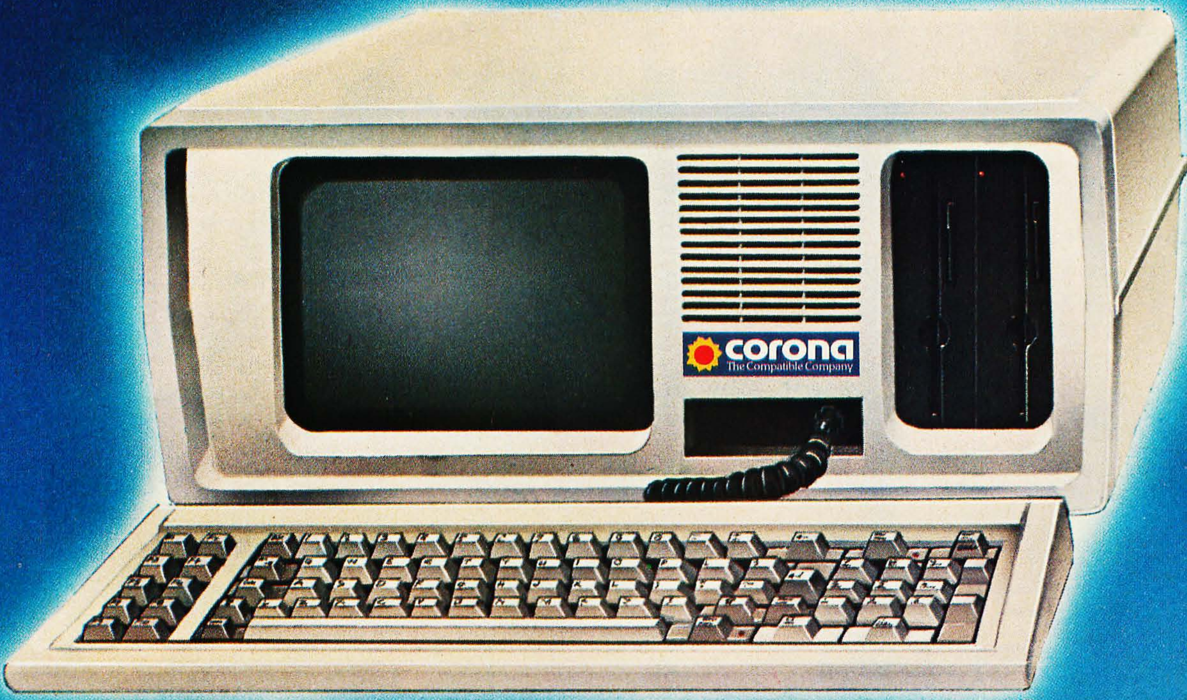

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Listing 1 continued:

```
        endif
        ifidn <&P_ST>,<st(i)>
          REG = Ø
        endif
        ifidn <&P_ST>,<st(I)>
          REG = Ø
        endif
endm


;*********************************************************************;
;*                                                                   ;
;*      CHK_CONC - Simple macro that will automatically insert       ;
;*                 WAIT statements AFTER every 8Ø87 instruction      ;
;*                 which accesses CPU main memory.  If variable      ;
;*                 "AUTOSYNC" <> Ø, then these WAITs will be         ;
;*                 inserted (providing no concurrency but relieving;
;*                 the programmer from worrying about synchronizing;
;*                 data references.  If the user program sets        ;
;*                 AUTOSYNC to a zero value, then no WAITS           ;
;*                 are inserted after the instructions and it is     ;
;*                 the user's responsibility to insure synch-        ;
;*                 ronization.                                       ;
;*                                                                   ;
;*********************************************************************;

CHK_CONC macro

        if AUTOSYNC
                WAIT    ; Automatic syncronization
        endif
endm


;*********************************************************************;
;                                                                     ;
;       CHOOSE_4 - Determine which of four parameters (XXX1 to XXX4)  ;
;                  should be used in ESC sequence, depending on P1    ;
;                  and P2 values.  P1 and P2 are parameters passed    ;
;                  by user in macro call.  XXX1 to XXX4 are macro-    ;
;                  dependent parameters tacked on to the call to      ;
;                  CHOOSE_4 by the specific 8Ø87 macro called by the  ;
;                  user code.                                         ;
;                                                                     ;
;*********************************************************************;

CHOOSE_4 macro P1,P2,XXX1,XXX2,XXX3,XXX4

        ; Initialize variables
        ZERO = Ø
        NOTZERO = Ø
        REG = Ø
        ;
        ; If user passed no parameters, (P1 and P2 are "blank") then
        ; issue a call to ESC_REG macro to set up proper ESC sequence.
        ; An arithmetic instruction with no operands is identical to the
        ; same instruction with the operand form "ST(1),ST".
        ; Example : "FDIV" - Divides second element on stack by first and
        ;                  places result in second element on stack.
        ;
        ifb <P1>
                REG = 1
                ESC_REG XXX1,REG
        else
          ;
  ; Check to see if first parameter (P1) passed by user is "ST".
  ; If yes, indicates that second parameter (P2) is of form "ST(i)"
  ; so use CHECK_ST macro to determine 'i'.  Then call ESC_REG macro
  ; to issue ESC sequence
  ; Example : "FADD ST,ST(4)" - Adds register four (fifth element on
  ;           8Ø87 stack) to top element and leaves result on top
  ;           of stack.
  ;
ifidn <P1>,<ST>
  CHECK_ST P2
  ZERO = REG + 1
  ife ZERO
    REG = 1
  endif
  ESC_REG XXX2,REG
else
ifidn <P1>,<st>
  CHECK_ST P2
  ZERO = REG + 1
  ife ZERO
    REG = 1
  endif
  ESC_REG XXX2,REG
else
  ;
  ; See if P1 is of form "ST(i)".  CHECK_ST returns with REG = -1
  ; if not, else REG = i (i from Ø to 7).  If of ST(i) form, assume
  ; P2 is ST (ie. operands are "ST(i),ST".  Use ESC_REG for ESC
  ; sequence
  ; Example :  "FSUB ST(3),ST" - Subtract top of stack from register
  ;            three (the fourth element down the stack) and leave
  ;            result in register 3.
  ;
  CHECK_ST P1
  NOTZERO = REG + 1
  if NOTZERO
    ESC_REG XXX1,REG
  else
    ;
    ; See if P1 indicates operation is "SHORT" real type.  If so,
    ; then P2 is address of source/destination and XXX3 sets up
    ; SHORT version of operation requested.
    ; Example : "FMUL SHORT VECTOR[SI]" - Multiply 32 bit number
    ;           found in memory at VECTOR offset from DS:SI address
    ;           by top of 8Ø87 stack and leave result on top of stack
    ;
    ifidn <P1>,<SHORT>
      ESC XXX3,P2
      CHK_CONC          ; Insert non-concurrent WAIT?
    else
    ifidn <P1>,<short>
      ESC XXX3,P2
      CHK_CONC          ; Insert non-concurrent WAIT?
    else
      ;
      ; See if P1 indicates a "LONG" real type.  If so, P2 is
      ; source/destination address and XXX4 is LONG opcode.
      ; Example : "FDIV LONG [BP].ID_NUMB" - Divide top of stack
      ;                by 64 bit number found at SS:BP + ID_NUMB
      ;                in memory.  Leave result on top of 8Ø87 stack
      ;
      ifidn <P1>,<LONG>
        ESC XXX4,P2
        CHK_CONC        ; Insert non-concurrent WAIT?
      else
      ifidn <P1>,<long>
        ESC XXX4,P2
        CHK_CONC        ; Insert non-concurrent WAIT?
      else
```

Listing 1 continued on page 340

Listing 1 continued:

```
                ;
                ; See if P1 indicates "TEMP" real type.  If so, P2 is
                ; source/destination and XXX2 is TEMP opcode.
                ; Example : "FLD TEMP INTERMEDIATE" - Load 80-bit temporary
                ;             real number from memory address INTERMEDIATE
                ;             onto top of 8087 stack
                ;
                ifidn <P1>,<TEMP>
                  ESC XXX2,P2
                  CHK_CONC       ; Insert non-concurrent WAIT?
                else
                ifidn <P1>,<temp>
                  ESC XXX2,P2
                  CHK_CONC       ; Insert non-concurrent WAIT?
                else
                  ;
                  ; If none of above, assume operation is of type "ST(i)"
                  ; and take appropriate action
                  ; Example : "FFREE ST(2)" - Free register 2 in 8087
                  ;
                  REG = 1
                  ESC_REG XXX2,REG
                endif
              endif
            endif
          endif
        endif
      endif
  endif
  endif
  endif
  endif
endm


;**************************************************************;
;                                                              ;
;       INT_SIZE - For all integer operations, determine proper ;
;               parameters to use in ESC sequence              ;
;                                                              ;
;**************************************************************;

INT_SIZE macro P1,P2,XXX_S,XXX_W,XXX_L

        ;
        ; Do "WORD" integer operation.
        ; Example : "FIMUL WORD PULSE_CNT[SI]" - Multiply 16 bit integer
        ;             value found at (DS:SI + PULSE_CNT) by top of stack
        ;             and leave result on top of stack
        ;
        ifidn <P1>,<WORD>
          ESC XXX_W,P2
        else
        ifidn <P1>,<word>

        ESC XXX_W,P2
      else
        ;
        ; Do "SHORT" integer operation.
        ; Example : "FISUB SHORT [BX].ANGLE" - Subtract 32 bit integer at
        ;             (SP:BX + ANGLE) in main memory from top of stack and
        ;             leave result on top of stack
        ;
        ifidn <P1>,<SHORT>
          ESC XXX_S,P2
        else
        ifidn <P1>,<short>
          ESC XXX_S,P2
        else
        ;
        ; Do "LONG" integer operation.
        ; Example : "FILD LONG POS_LABEL" - Load 64-bit integer onto top
        ;             of stack from main memory at POS_LABEL
        ;
        ifidn <P1>,<LONG>
          ESC XXX_L,P2
        else
        ifidn <P1>,<long>
          ESC XXX_L,P2
        else
          ERROR IN macro !!!
        endif
      endif
    endif
  endif
  endif
  endif

  CHK_CONC       ; Insert non-concurrent WAIT?

endm


;**************************************************************;
;*                                                             ;
;*              DEFINE ALL 8087 MNEMONICS HERE                 ;
;*                  (In alphabetical order)                    ;
;*                                                             ;
;**************************************************************;


FABS    macro           ; Absolute value - No operands
        WAIT            ; Synchronization cmd
        ESC 0CH,CX
endm

FADD    macro   P1,P2   ; Add real - //source/destination,source
                        ;       //ST,ST(i)/ST(i),ST/short-real/long-real
        ifb  <P1>       ; If no parameters, classical stack - discard operands
                FADDP ST(1),ST
        else
                WAIT    ; Synchronization cmd
                CHOOSE_4 P1,P2,20H,00H,00H,20H
        endif
endm

FADDP   macro   P1,P2   ; Add real and pop - destination,source
                        ;       ST(i),ST
        WAIT            ; Synchronization cmd
        CHOOSE_4 P1,,30H
endm

FBLD    macro   P1      ; Packed decimal (BCD) load - source
                        ;       packed-decimal
        WAIT            ; Synchronization cmd
        ESC 3CH,P1
endm

FBSTP   macro   P1      ; Packed decimal (BCD) store and pop - destination
                        ;       packed-decimal
        WAIT            ; Synchronization cmd
        ESC 3EH,P1
endm

FCHS    macro           ; Change sign - No operands
        WAIT            ; Synchronization cmd
        ESC 0CH,AX
```

Listing 1 continued on page 342

Circle 104 on inquiry card. ⟶

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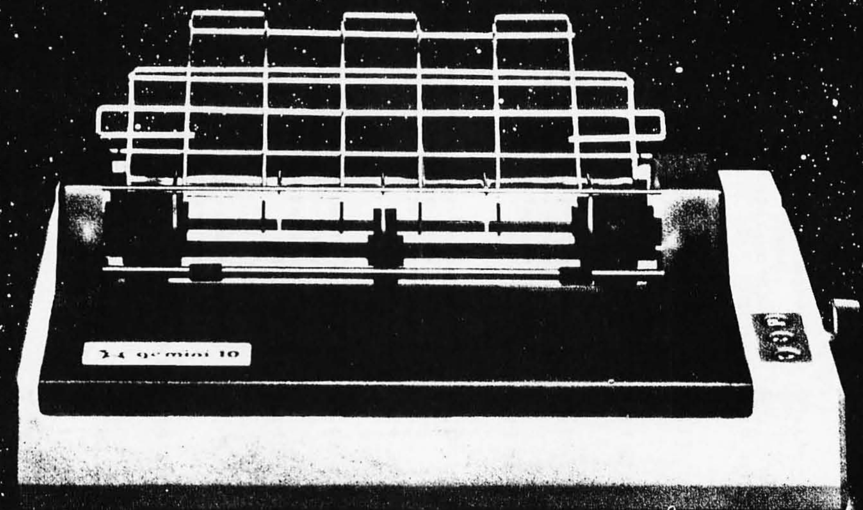

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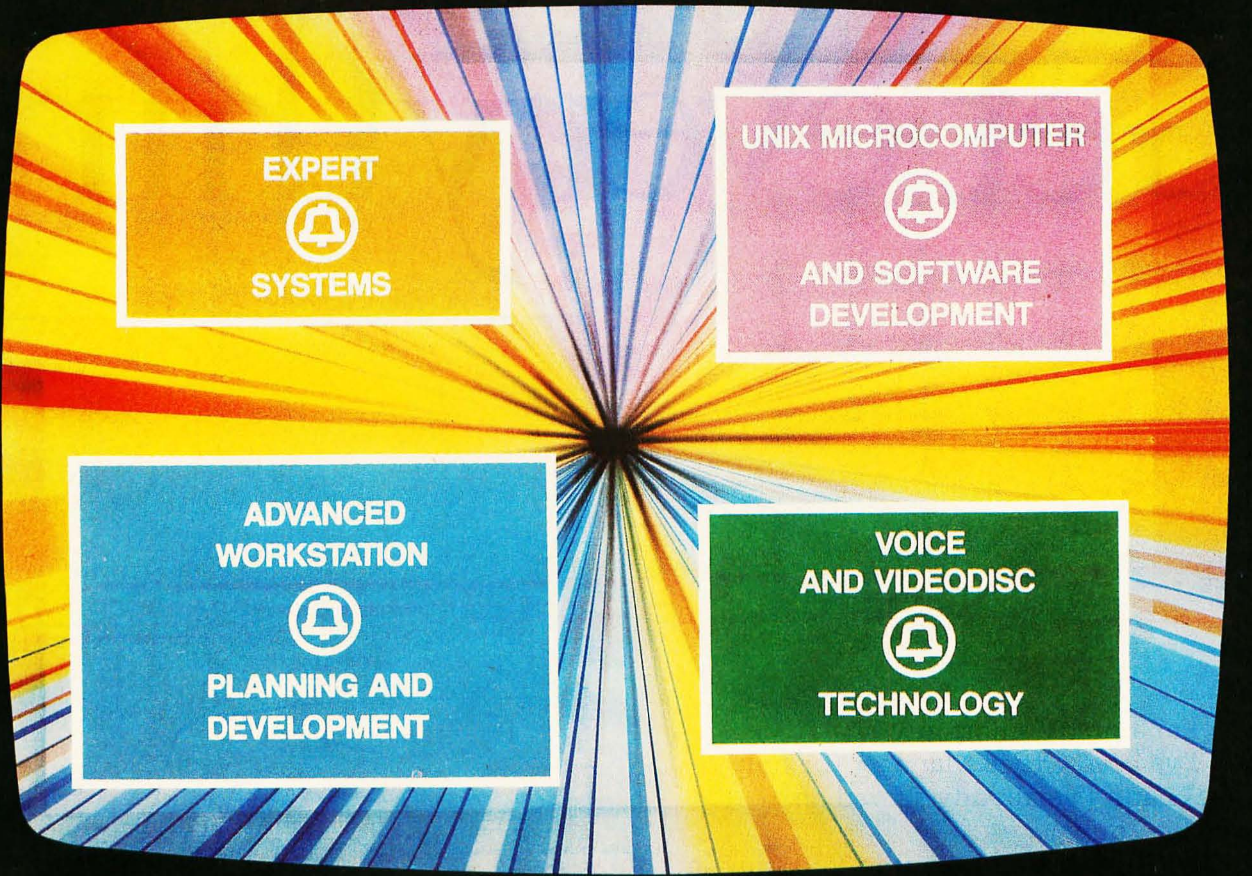
Listing 1 continued:

```
endm

FCLEX   macro               ; Clear exceptions - No operands
        WAIT                ; Synchronization cmd
        FNCLEX              ;
endm

FCOM    macro   P1,P2       ; Compare real - //source
                            ;       //ST(i)/short-real/long-real
        WAIT                ; Synchronization cmd
        CHOOSE_4 P1,P2,Ø2H,,Ø2H,22H
endm

FCOMP   macro   P1,P2       ; Compare real and pop - //source
                            ;       //ST(i)/short-real/long-real
        WAIT                ; Synchronization cmd
        CHOOSE_4 P1,P2,Ø3H,,Ø3H,23H
endm

FCOMPP  macro               ; Compare real and pop twice - No operands
        WAIT                ; Synchronization cmd
        ESC 33H,CX
endm

FDECSTP macro               ; Decrement stack pointer - No operands
        WAIT                ; Synchronization cmd
        ESC ØEH,SI
endm

FDISI   macro               ; Disable interrupts - No operands
        WAIT                ; Synchronization cmd
        FNDISI              ;
endm

FDIV    macro   P1,P2       ; Divide real - //source/destination,source
                            ;       //ST(i),ST/short-real/long-real
        ifb  <P1>           ; If no parameters, classical stack - discard operands
                FDIVP ST(1),ST
        else
                WAIT    ; Synchronization cmd
                CHOOSE_4 P1,P2,26H,Ø6H,Ø6H,26H
        endif
endm

FDIVP   macro   P1,P2       ; Divide real and pop - destination,source
                            ;       ST(i),ST
        WAIT                ; Synchronization cmd
        CHOOSE_4 P1,,36H
endm

FDIVR   macro   P1,P2       ; Divide real reversed - //source/destination,source
                            ;       //ST,ST(i)/ST(i),ST/short-real/long-real
        ifb  <P1>           ; If no parameters, classical stack - discard operands
                FDIVRP ST(1),ST
        else
                WAIT            ; Synchronization cmd
                CHOOSE_4 P1,P2,27H,Ø7H,Ø7H,27H
        endif
endm

FDIVRP  macro   P1,P2       ; Divide real reversed and pop - destination,source
                            ;       ST(i),ST
        WAIT                ; Synchronization cmd
        CHOOSE_4 P1,,37H
endm

FENI    macro               ; Enable interrupts - No operands
        WAIT                ; Synchronization cmd
        FNENI               ;
endm

FFREE   macro   P1          ; Free register - destination
                            ;       ST(i)
        WAIT                ; Synchronization cmd
        CHOOSE_4 P1,,28H
endm

FIADD   macro   P1,P2       ; Integer add - source
                            ;       word-integer/short-integer
        WAIT                ; Synchronization cmd
        INT_SIZE P1,P2,1ØH,3ØH
endm

FICOM   macro   P1,P2       ; Integer compare - source
                            ;       word-integer/short-integer
        WAIT                ; Synchronization cmd
        INT_SIZE P1,P2,12H,32H
endm

FICOMP  macro   P1,P2       ; Integer compare and pop
                            ;       word-integer/short-integer
        WAIT                ; Synchronization cmd
        INT_SIZE P1,P2,13H,33H
endm

FIDIV   macro   P1,P2       ; Integer divide - source
                            ;       word-integer/short-integer
        WAIT                ; Synchronization cmd
        INT_SIZE P1,P2,16H,36H
endm

FIDIVR  macro   P1,P2       ; Integer divide reversed - source
                            ;       word-integer/short-integer
        WAIT                ; Synchronization cmd
        INT_SIZE P1,P2,17H,37H
endm

FILD    macro   P1,P2       ; Integer load - source
                            ;       word-integer/short-integer/long-integer
        WAIT                ; Synchronization cmd
        INT_SIZE P1,P2,18H,38H,3DH
endm

FIMUL   macro   P1,P2       ; Integer multiply - source
                            ;       word-integer/short-integer
        WAIT                ; Synchronization cmd
        INT_SIZE P1,P2,11H,31H
endm

FINCSTP macro               ; Increment stack pointer - No operands
        WAIT                ; Synchronization cmd
        ESC ØEH,DI
endm

FINIT   macro               ; Initialize processor - No operands
        WAIT                ; Synchronization cmd
        FNINIT              ;
endm

FIST    macro   P1,P2       ; Integer store - destination
                            ;       word-integer/short-integer
        WAIT                ; Synchronization cmd
        INT_SIZE P1,P2,1AH,3AH
endm

FISTP   macro   P1,P2       ; Integer store and pop - destination
                            ;       word-integer/short-integer/long-integer
        WAIT                ; Synchronization cmd
```

Listing 1 continued on page 347



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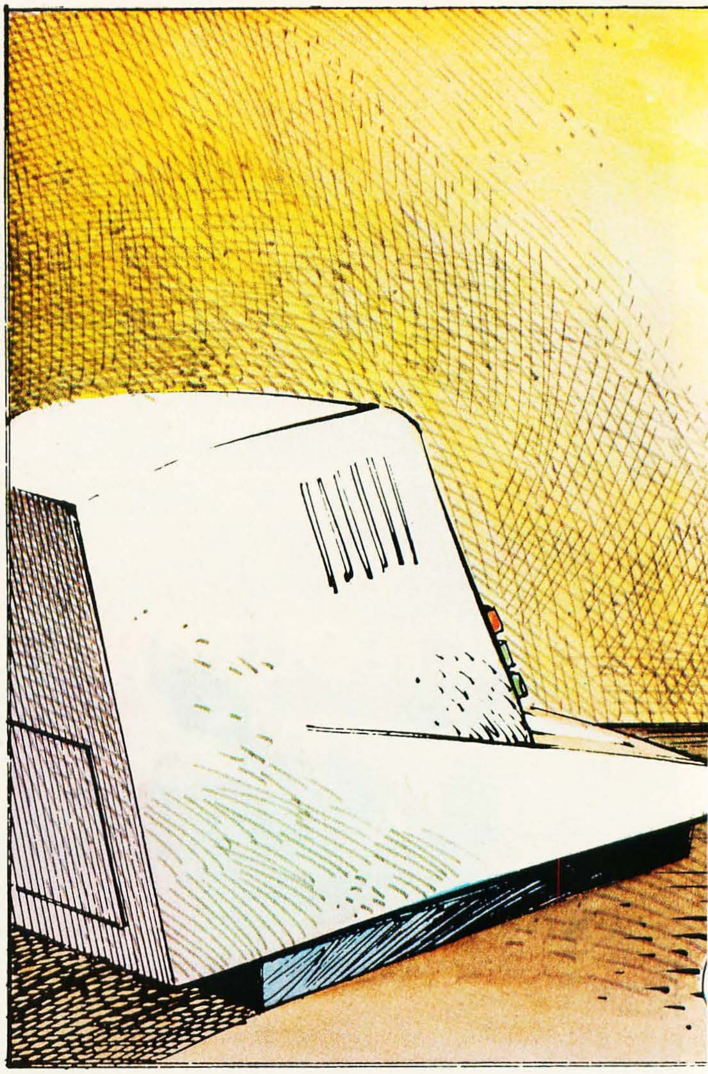

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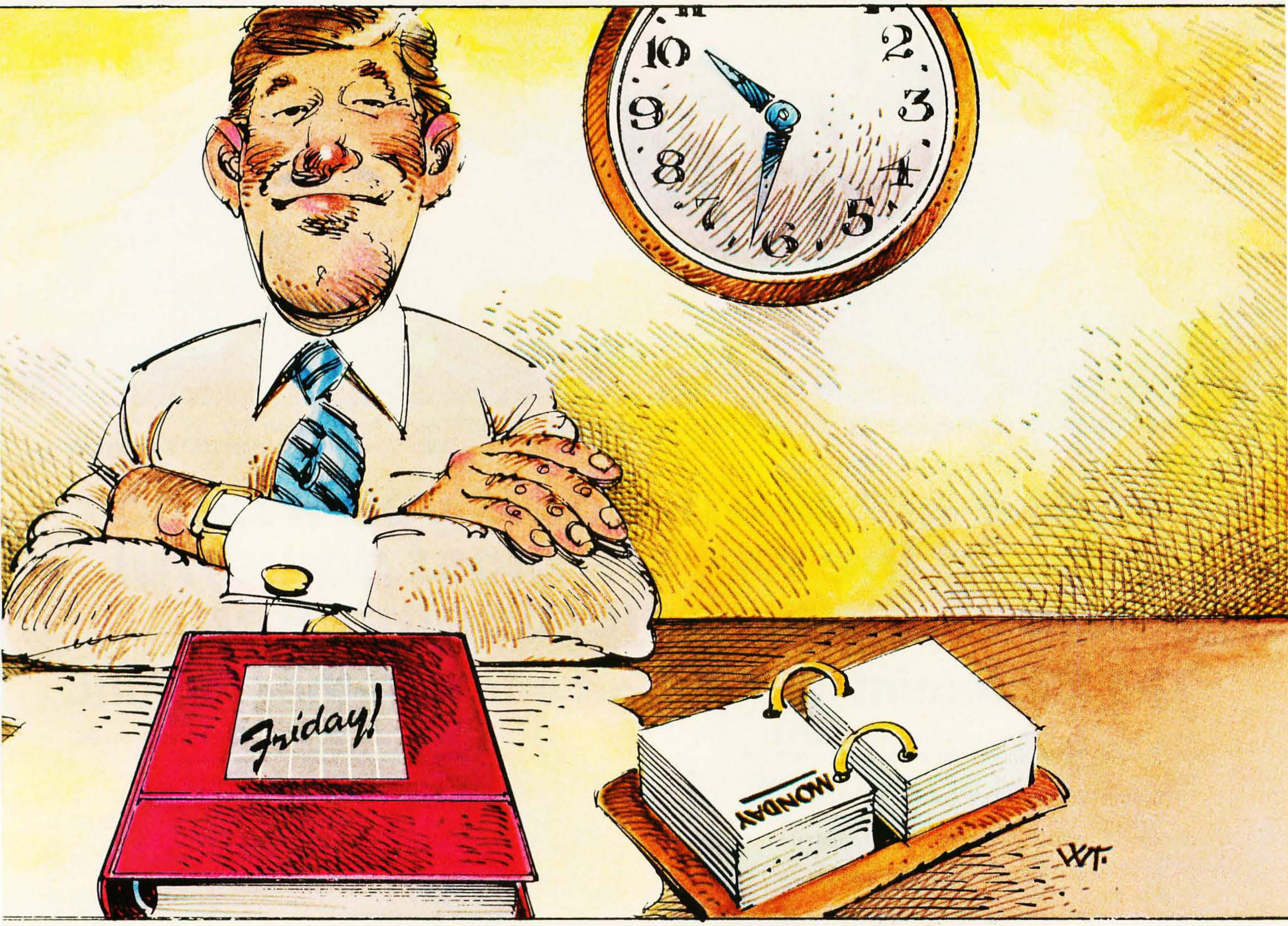

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Listing 1 continued:

```
        INT_SIZE P1,P2,1BH,3BH,3FH
endm

FISUB   macro   P1,P2   ; Integer subtract - source
                        ;       word-integer/short-integer
        WAIT            ; Synchronization cmd
        INT_SIZE P1,P2,14H,34H
endm

FISUBR  macro   P1,P2   ; Integer subtract reversed - source
                        ;       word-integer/short-integer
        WAIT            ; Synchronization cmd
        INT_SIZE P1,P2,15H,35H
endm

FLD     macro   P1,P2   ; Load real - source
                        ;       ST(i)/short-real/long-real/temp-real
        WAIT            ; Synchronization cmd
        CHOOSE_4 P1,P2,ØBH,1DH,ØBH,2BH ; 1DH INDICATES TEMPORARY REAL !!
endm

FLDCW   macro   P1      ; Load control word - source
                        ;       2-bytes
        WAIT            ; Synchronization cmd
        ESC ØDH,P1
endm

FLDENV  macro   P1      ; Load environment - source
                        ;       14-bytes
        WAIT            ; Synchronization cmd
        ESC ØCH,P1
endm

FLDLG2  macro           ; Load log 2 (base 1Ø) - No operands
        WAIT            ; Synchronization cmd
        ESC ØDH,SP
endm

FLDLN2  macro           ; Load log 2 (base e) - No operands
        WAIT            ; Synchronization cmd
        ESC ØDH,BP
endm

FLDL2E  macro           ; Load log e (base 2) - No operands
        WAIT            ; Synchronization cmd
        ESC ØDH,DX
endm

FLDL2T  macro           ; Load leg 1Ø (base 2) - No operands
        WAIT            ; Synchronization cmd
        ESC ØDH,CX
endm

FLDPI   macro           ; Load pi - No operands
        WAIT            ; Synchronization cmd
        ESC ØDH,BX
endm

FLDZ    macro           ; Load +Ø.Ø - No operands
        WAIT            ; Synchronization cmd
        ESC ØDH,SI
endm

FLD1    macro           ; Load +1.Ø - No operands
        WAIT            ; Synchronization cmd
        ESC ØDH,AX
endm
```

```
FMUL    macro   P1,P2   ; Multiply real - //source/destination,source
                        ;       //ST(i),ST/ST,ST(i)/short-real/long-real
        ifb  <P1>       ; If no parameters, classical stack - discard operands
                FMULP ST(1),ST
        else
                WAIT    ; Synchronization cmd
                CHOOSE_4 P1,P2,21H,Ø1H,Ø1H,21H
        endif
endm

FMULP   macro   P1,P2   ; Multiply real and pop - destination,source
                        ;       ST(i),ST
        WAIT            ; Synchronization cmd
        CHOOSE_4 P1,,31H
endm

FNCLEX  macro           ; Clear exceptions - No wait FCLEX
        ESC 1CH,DX      ;
endm

FNDISI  macro           ; Disable interrupts - No wait FDISI
        ESC 1CH,CX      ;
endm

FNENI   macro           ; Enable interrupts - No wait FENI
        ESC 1CH,AX      ;
endm

FNINIT  macro           ; Initialize processor - No wait FINIT
        ESC 1CH,BX      ;
endm

FNOP    macro           ; No operation - No operands
        WAIT            ; Synchronization cmd
        ESC ØAH,AX
endm

FNSAVE  macro   P1      ; Save state - destination (No wait FSAVE)
                        ;       94-bytes
        ESC 2EH,P1      ;
endm

FNSTCW  macro   P1      ; Store control word - destination (No wait FSTCW)
                        ;       2-bytes
        ESC ØFH,P1      ;
endm

FNSTENV macro   P1      ; Store environment - destination (No wait FSTENV)
                        ;       14-bytes
        ESC ØEH,P1      ;
endm

FNSTSW  macro   P1      ; Store status word - destination (No wait FSTSW)
                        ;       2-bytes
        ESC 2FH,P1      ;
endm

FPATAN  macro           ; Partial arctangent - No operands
        WAIT            ; Synchronization cmd
        ESC ØEH,BX
endm

FPREM   macro           ; Partial remainder - No operands
        WAIT            ; Synchronization cmd
        ESC ØFH,AX
endm
```

Listing 1 continued on page 348

Listing 1 continued:

```
FPTAN   macro           ; Partial tangent - No operands
        WAIT            ; Synchronization cmd
        ESC ØEH,DX
endm

FRNDINT macro           ; Round to integer - No operands
        WAIT            ; Synchronization cmd
        ESC ØFH,SP
endm

FRSTOR  macro   P1      ; Restore saved state - source
                        ;       94-bytes
        WAIT            ; Synchronization cmd
        ESC 2CH,P1
endm

FSAVE   macro   P1      ; Save state - destination
                        ;       94-bytes
        WAIT            ; Synchronization cmd
        FNSAVE P1       ;
endm

FSCALE  macro           ; Scale - No operands
        WAIT            ; Synchronization cmd
        ESC ØFH,BP
endm

FSQRT   macro           ; Square root - No operands
        WAIT            ; Synchronization cmd
        ESC ØFH,DX
endm

FST     macro   P1,P2   ; Store real - destination
                        ;       ST(i)/short-real/long-real
        WAIT            ; Synchronization cmd
        CHOOSE_4 P1,P2,2AH,,ØAH,2AH
endm

FSTCW   macro   P1      ; Store control word - destination
                        ;       2-bytes
        WAIT            ; Synchronization cmd
        FNSTCW P1       ;
endm

FSTENV  macro   P1      ; Store environment - destination
                        ;       14-bytes
        WAIT            ; Synchronization cmd
        FNSTENV P1      ;
endm

FSTP    macro   P1,P2   ; Store real and pop - destination
                        ;       ST(i)/short-real/long-real/temp-real
        WAIT            ; Synchronization cmd
        CHOOSE_4 P1,P2,2BH,1FH,ØBH,2BH ; 1FH INDICATES TEMPORARY REAL !!
endm

FSTSW   macro   P1      ; Store status word - destination
                        ;       2-bytes
        WAIT            ; Synchronization cmd
        FNSTSW P1       ;
endm

FSUB    macro   P1,P2   ; Subtract real - //source/destination,source
                        ;       //ST,ST(i)/ST(i),ST/short-real/long-real
        ifb  <P1>       ; If no parameters, classical stack - discard operands
                FSUBP ST(1),ST
        else
                WAIT    ; Synchronization cmd
                CHOOSE_4 P1,P2,24H,Ø4H,Ø4H,24H
        endif
endm

FSUBP   macro   P1,P2   ; Subtract real and pop - destination,source
                        ;       ST(i),ST
        WAIT            ; Synchronization cmd
        CHOOSE_4 P1,,34H
endm

FSUBR   macro   P1,P2   ; Subtract real reversed - //source/destination,source
                        ;       //ST,ST(i)/ST(i),ST/short-real/long-real
        ifb  <P1>       ; If no parameters, classical stack - discard operands
                FSUBRP ST(1),ST
        else
                WAIT            ; Synchronization cmd
                CHOOSE_4 P1,P2,25H,Ø5H,Ø5H,25H
        endif
endm

FSUBRP  macro   P1,P2   ; Subtract real reversed and pop - destination,source
                        ;       ST(i),ST
        WAIT            ; Synchronization cmd
        CHOOSE_4 P1,,35H
endm

FTST    macro           ; Test stack top against +Ø.Ø - No operands
        WAIT            ; Synchronization cmd
        ESC ØCH,SP
endm

FWAIT   macro           ; (CPU) Wait while 8Ø87 is busy - No operands
        WAIT            ; NOTE : CPU instruction, not escape code
endm

FXAM    macro           ; Examine stack top - No operands
        WAIT            ; Synchronization cmd
        ESC ØCH,BP
endm

FXCH    macro   P1      ; Exchange registers - //destination
                        ;       //ST(i)
        WAIT            ; Synchronization cmd
        CHOOSE_4 P1,,Ø9H
endm

FXTRACT macro           ; Extract exponent and significand - No operands
        WAIT            ; Synchronization cmd
        ESC ØEH,SP
endm

FYL2X   macro           ; Y * log X (base 2) - No operands
        WAIT            ; Synchronization cmd
        ESC ØEH,CX
endm

FYL2XP1 macro           ; Y * log (X+1) (base 2) - No operands
        WAIT            ; Synchronization cmd
        ESC ØFH,CX
endm

F2XM1   macro           ; (2^^X - 1) - No operands
        WAIT            ; Synchronization cmd
        ESC ØEH,AX
endm

endif

AUTOSYNC=1      ; Initialize M8Ø87 to automatic synchronization
```

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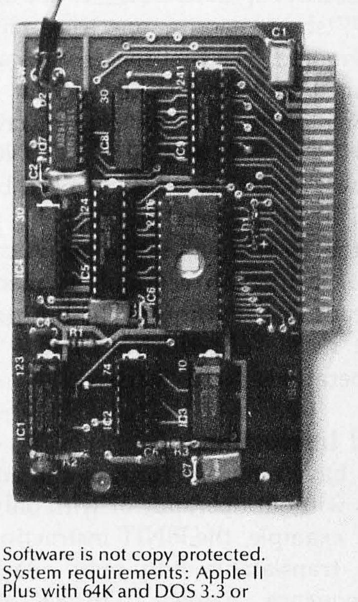

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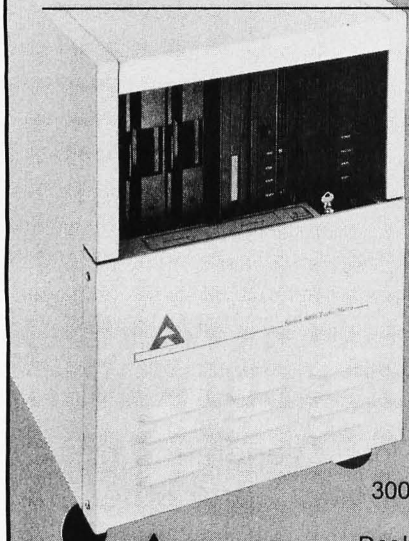

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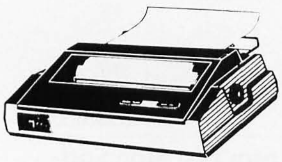

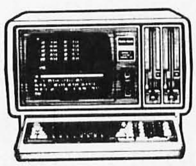

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Text continued from page 332:

freely intermix standard 8088 CPU and 8087 mnemonics in assembly-language programs and then let the macro assembler take care of correctly converting the 8087 instructions into the proper escape codes.

The support package, named M8087.MAC (referred to throughout this article as M8087), uses Intel's mnemonic names for the 8087 instruction set listed in table 1. Because only 8087 instructions begin with the letter "F," it is easy to skim through an assembly-language listing and pick out the appropriate instructions.

The software support package M8087 requires the use of MASM, part of the IBM Macro Assembler package, and at least 96K bytes of RAM (random-access read/write memory). This file of 83 macros presented in listing 1 allows full and easy access to the entire 8087 instruction set at a level equivalent to assembly-language programming.

M8087 is intended to be placed in a separate file (I named mine M8087.MAC and placed it on the disk that contains the macro assembler). The complete package can then be used simply by placing the statement "INCLUDE M8087.MAC" (or some variation such as "INCLUDE A:M8087.MAC", etc.) in the assembly-language program somewhere near its start. This instruction causes the assembler to go to the appropriate disk drive, locate the file M8087.MAC, and read it into the program.

Once M8087 resides on the MASM disk, the single INCLUDE statement provides access to these 8087 mnemonics from any number of programs. Any valid 8087 mnemonic instruction will automatically be expanded into the correct escape sequence at assembly time.

If you look through listing 1, you will notice five long and involved macros at the start (ESC_REG, CHECK_ST, CHK_CONC, CHOOSE_4, and INT_SIZE) followed by 77 short macros, one for each Intel 8087 instruction mnemonic. The first five macros are all nested macros (defined and/or invoked within other macros) called by some of the 77 instruction macros. In fact, ESC_REG, CHECK_ST, and CHK_CONC are nested two levels down because they are invoked by the CHOOSE_4 and INT_SIZE nested macros.

Let's first look at the 77 instruction macros. A careful analysis of the 8087 instruction set and its machine-language op codes leads to a division of the instructions into four types that I call "directly translated," "nonwaiting," "integer operations," and "variety."

Directly Translated Instructions

These instructions have only one form of call and include all instructions without operands or with only one type of operand. For example, the FINIT instruction has only a single form translatable into only one valid machine-language sequence, namely "DB E3" (hexadecimal). (For a full list of all the 8087 op codes, see appendix A of Intel's *Numerics Supplement to the 8086 Family User's Guide*.)

The macro for a directly translated instruction can immediately issue the appropriate ESC sequence for the macro invocation because the form is known in advance.

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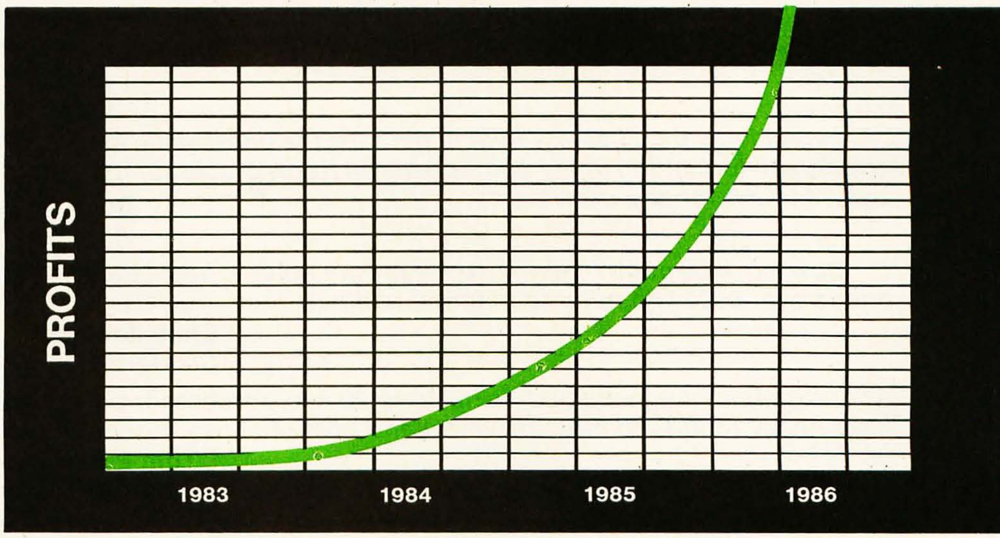

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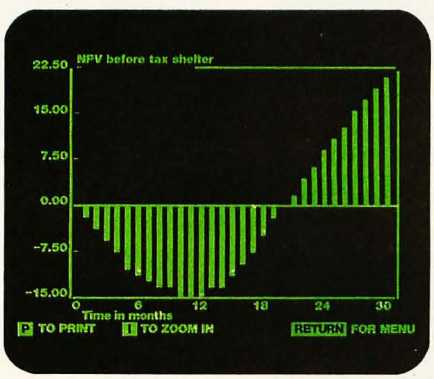

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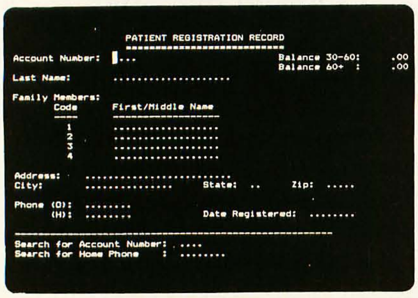

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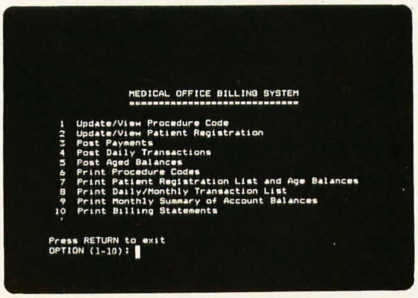

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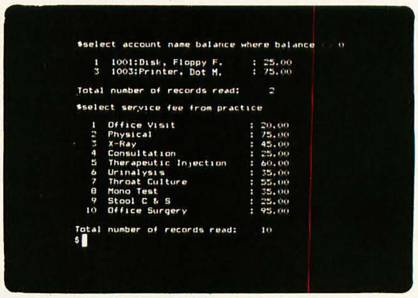

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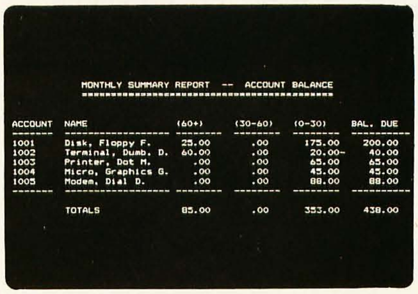

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This instruction type accounts for half of the 8087 instruction set or a total of 38 macros.

Nonwaiting Instructions

The *nonwaiting instructions* are a set of eight mnemonics that Intel defined to help prevent deadlocking the 8087 under special conditions. Notice from listing 1 that, in most of the 77 instruction macros, the first line of the macro definition is a WAIT mnemonic. This is interpreted by the assembler as the normal 8088 WAIT instruction and is assembled as such. This causes the 8088 CPU to wait on the 8087 to finish any current task before beginning the next operation. (When an 8087 and an 8088 are correctly interconnected, the BUSY pin of the 8087 NDP is tied to the WAIT pin of the 8088 CPU. The 8088 WAIT instruction, when executed, waits for the signal on the TEST pin to go low. Because the 8087 holds the BUSY line high while it is executing an instruction, a WAIT instruction executed immediately before an 8087 instruction ensures that the program will not give the 8087 an instruction before it is ready to execute it.)

The WAITs are automatically inserted before all operations except the eight nonwaiting instructions FNCLEX, FNDISI, FNENI, FNINIT, FNSAVE, FNSTCW, FNSTENV, and FNSTSW. For each of these, Intel also specifies a waiting form (FCLEX, FDISI, FENI, FINIT, FSAVE, FSTCW, FSTENV, and FSTSW). An in-depth look at why these instructions are special is beyond the scope of this article and will not be necessary for most applications of the 8087 on the IBM PC. (For more information, see Intel's *Numerics Supplement* book mentioned earlier.) Suffice it to say that the nonwaiting instructions are handled in the same manner as the directly translated types without preceding the escape sequence with a WAIT command.

Integer Operation Instructions

These instructions deal with integer operations, which on the 8087 always use an integer operand from memory as a source. The three types of integer operands are word-integer (16 bits), short-integer (32 bits), and long-integer (64 bits).

The integer operation instruction is implemented as a macro by use of the INT_SIZE nested macro. All macro invocations of an integer instruction must specify the type of operand followed by the memory address at which that integer operand is to be found. For example:

```
FIADD WORD CURRENT_SPEED
    ; where CURRENT_SPEED is a
    ; label to a memory location
```

or

```
FIMUL SHORT [BP].SEQUENCE
    ; where register BP is index
    ; offset by value in SEQUENCE
```


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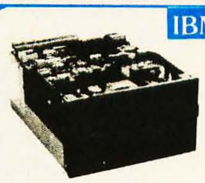

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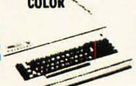

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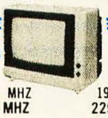

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The integer macros receive two parameters, P1 and P2, from the user's program. P1 specifies the type of operand ("WORD" and "SHORT" from the examples above). P2 contains the memory address and can be any valid addressing scheme permitted by the assembler ("CURRENT_SPEED" and "[BP].SEQUENCE" from the examples above).

The integer macros then turn and call the INT_SIZE macro, passing to it the two parameters as well as up to three other parameters (XXX_S, XXX_W, and XXX_L—see the definition of INT_SIZE in listing 1). These are individual values that form part of the escape sequence depending on whether the type parameter is WORD (XXX_W), SHORT (XXX_S), or LONG (XXX_L).

The INT_SIZE macro uses the conditional assembly-language pseudo-ops to compare the type strings and determine which escape sequence to use. If the operand type is none of the valid or expected types, then an "ERROR in macro" message is inserted instead of an escape sequence, causing an assembly-language error to occur later.

Variety Instructions

The last type of instruction macro is variety and includes the 19 remaining instructions. Basically, these instructions are similar in that the source operand can be specified in a variety of ways, including the classical stack, register, and real-memory forms.

The variety macro type uses the CHOOSE_4 nested macro to issue the proper escape sequence. The instruction macro passes to CHOOSE_4 any parameters it received in its invocation (from the user program) as well as some instruction-specific parameters. CHOOSE_4 then examines its parameters (as many as six) and determines what the escape sequence should be.

The classical stack and register variations of the variety type include four types of operands: none, "ST(*i*)" (for single-operand instructions), "ST,ST(*i*)", and "ST(*i*),ST". CHOOSE_4 receives the operands as dummy parameters P1 and P2. In place of the *i* will be the user-specified register number (0 to 7) used to determine the escape sequence.

The variety instruction type includes all the real-number instructions (such as FADD, FSUB, FDIV, etc.). These real-number instructions can be of the classical stack or register type just mentioned or of the real-memory type. The real-memory operand type specifies that the source operand is found somewhere in the 8088 memory space. The operands of this type can be of various lengths ("SHORT", "LONG", and "TEMP"). Examples of the variety instructions are

```
FLD ST(4)
   ; Push stack once and move contents of reg 4
   ; to top of stack
FADD SHORT DISTANCE
   ; Add "short" real-memory operand found
   ; at memory address "DISTANCE" to top
   ; value on stack, leave result on TOS
FDIVP ST(4),ST
```

Text continued on page 358

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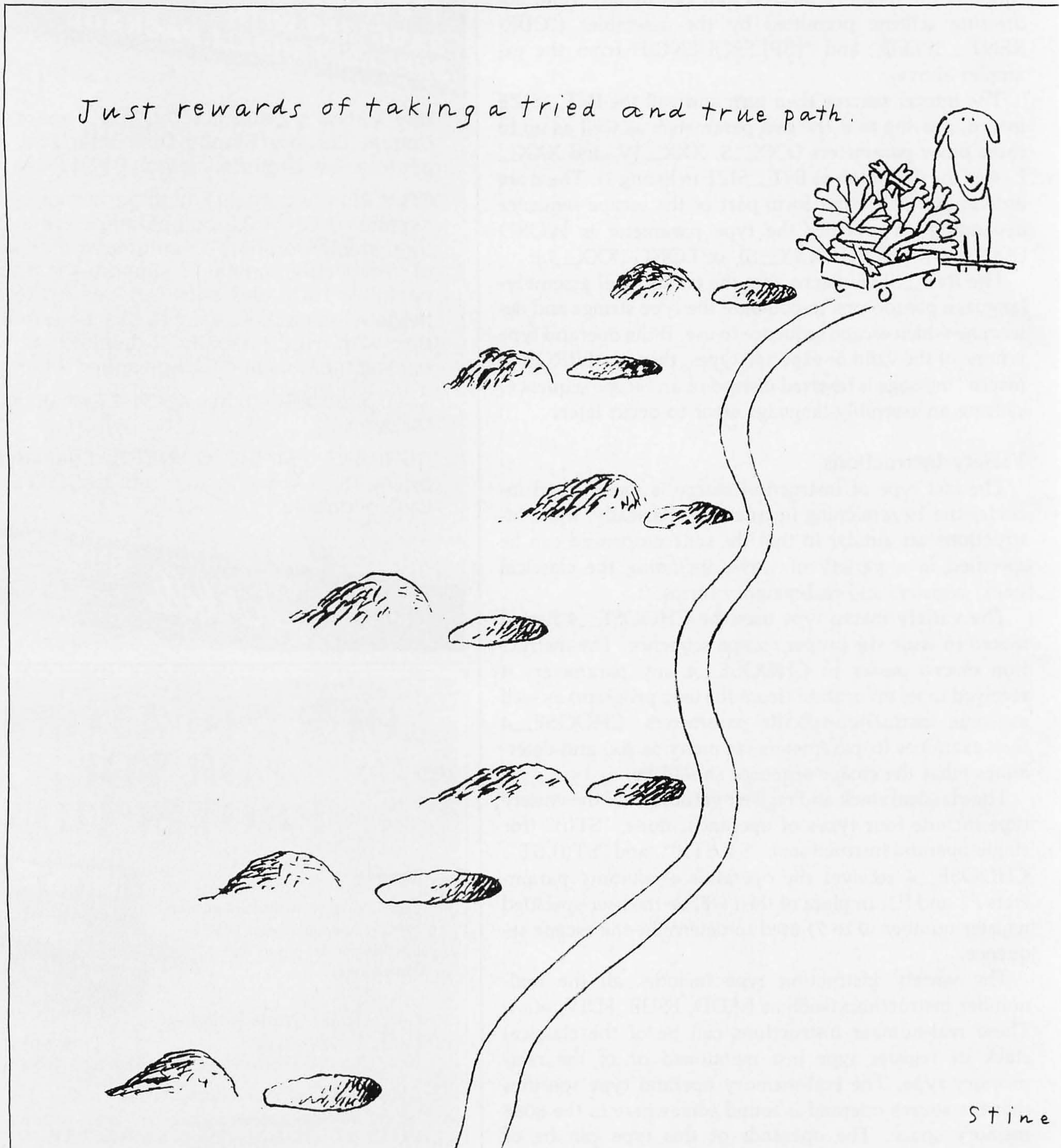

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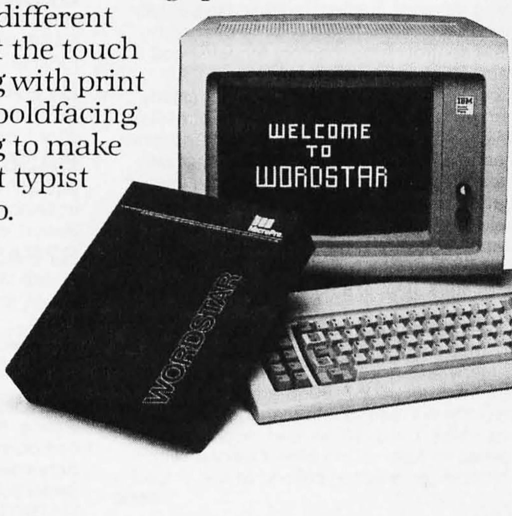

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Text continued from page 355:

```
; Divide top of stack into reg 4
; in 8087 reg set and leave result in
; reg 4, pop top-of-stack after done
```

The CHOOSE_4 macro uses two submacros: CHECK_ST and ESC_REG. CHECK_ST is called with a parameter that CHOOSE_4 thinks is in the range "ST(0)" to "ST(7)" (from ST(*i*)). If it is in this range, CHECK_ST returns a value "REG" equal to *i*, which is then used in the escape sequence. If the parameter string is not in this range, then REG is set equal to −1 and is returned.

Once the CHOOSE_4 macro determines that the instruction is using the "ST(*i*)" form and determines *i*, it invokes ESC_REG to determine the final escape sequence for the instruction. If the instruction is a real-memory type, CHOOSE_4 itself issues the escape-sequence instruction for the assembler.

Each of the 77 instruction macros in listing 1 is fully commented to specify the legal operands and types for that instruction. When specifying an operand from memory for either the integer or real operations, the user program must specify the type of operand to be used. The instruction form should be <operation-name operand-type operand-address>. Valid types for integers are WORD, SHORT, and LONG. Valid types for reals include SHORT, LONG, and TEMP. Only the FILD and FISTP (integer load, integer store and pop) instructions use long integers. Likewise, only the FLD and FSTP (real-number load, real-number store and pop) instructions use temporary reals. Here are two 8087 instructions that use operands from memory:

```
FIADD       WORD        INT_ADDR
;
; adds WORD-integer (16 bits) found at
; INT_ADDR to top value on 8087 stack.
; Result is left on top of stack.
;
FADD        LONG        [BX].TIME_VAL
;
; adds LONG-real (64 bits) found by indexing
; off of 8088 CPU internal register BX plus
; offset TIME_VAL to top value on 8087 stack
;
```

Because M8087 is designed to be as efficient as possible, it does not contain much error-checking capability. Therefore, you may discover invalid operand types in 8087 instructions that M8087 will happily translate into some incorrect escape sequence. The results of any such occurrence are undefined.

For example, if you try to assemble the invalid command "FADD TEMP VARIABLE" (invalid because FADD can use only short and long real-memory variables, not temporary reals), M8087 will not spot this as an error. The valid operand types for all 8087 instruc-

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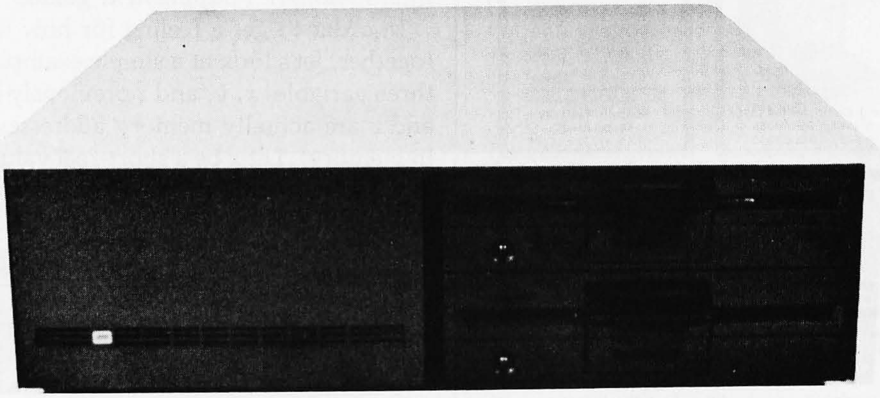

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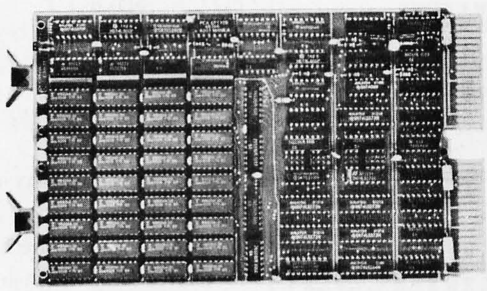

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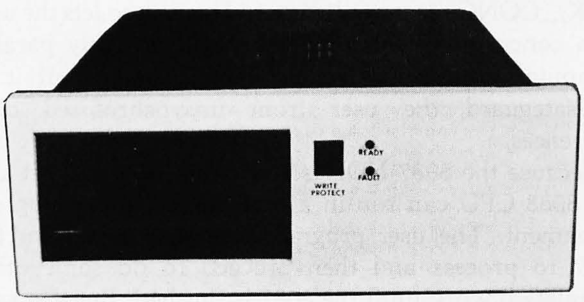

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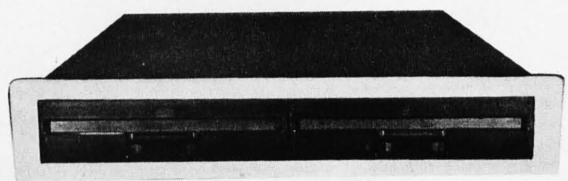

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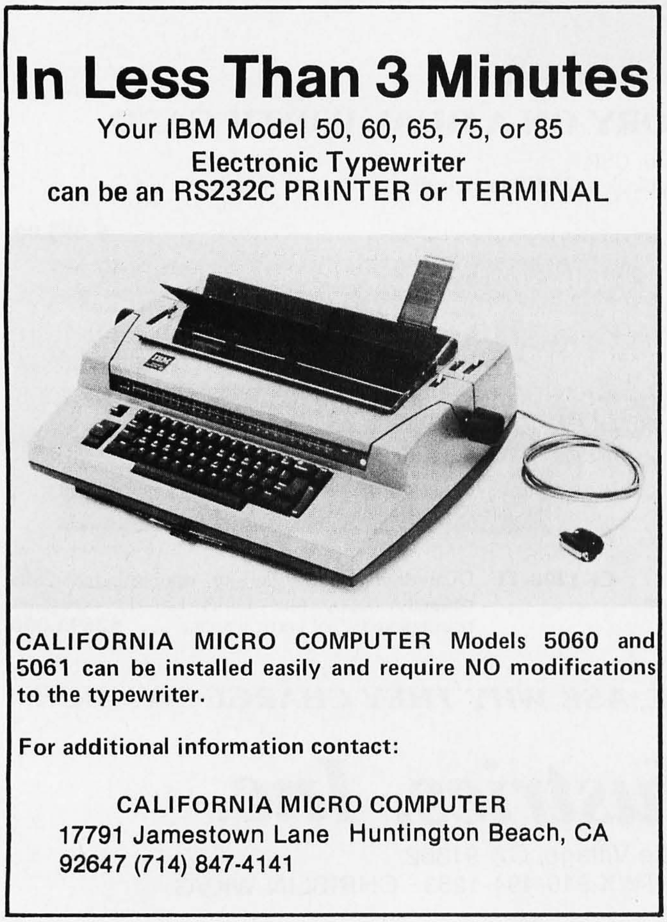

tions are documented in the comments of each instruction macro shown in listing 1. They are also documented in Intel's *Numerics Supplement* guide.

In order to get a feeling for how the 8087 code is put together, let's look at a simple example. Suppose we have three variables x, y, and z previously defined (where x, y, and z are actually memory addresses to numbers stored in memory). Let x be a short-real value, y a word-integer, and z a long-real. Suppose that we wish to calculate the following:

$$x = \frac{(x^2 + y^2)}{x + y} + \sqrt{(z - y)}$$

One solution is

```
FLD     LONG z    ; Load z into 8087 stack (TOS)
FISUB   WORD y    ; Subtract integer y from z, leave
                  ;    TOS
FSQRT             ; Take square root of x-y
FLD     SHORT x   ; Load short-real x
FMUL    ST,ST(0)  ; Multiply by itself to get x-squared
FILD    WORD y    ; Load word-integer y
FMUL    ST,ST(0)  ; Get y-squared
FADD              ; Add x-squared to y-squared
FLD     SHORT x   ; Load short-real x again
FIADD   WORD y    ; Add word-integer y to x
FDIV              ; Divide (x+y) into (x²+y²)
FADD              ; Add result to √(z-y)
FST     SHORT x   ; Store result back as short-real x
```

It is important to stress at this point that this series of instructions is now available at the assembly-language level because of the M8087 package. What has happened is that many high-level functions usually reserved for languages such as BASIC or Pascal are now available for easy use by the lowly assembly-language program.

8087 Synchronization

The final topic that we must look at relates to the CHK_CONC macro in listing 1. This macro lets the user turn concurrency checking off to allow highly parallel computations to be performed when desired or turn it on to safeguard the user from unsynchronized data references.

Because the 8087 NDP is a separate processor, it and the 8088 CPU can run in a true parallel processing environment. The user program can issue a task for the 8087 to process and then proceed to do some other (unrelated) work until the 8087 is finished. But this very freedom results in some dangerous computational situations.

You must be very careful when allowing the 8087 and the CPU to run simultaneously not to allow the CPU code to interfere with the 8087 working on its task. The big problem comes when both the 8087 and the CPU wish to update the same variable. Access to that variable must be controlled so that one processor at a time has exclusive rights to it, and the desired sequence of accessing that variable is achieved.

To aid the novice user of the 8087, I have included the

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Unfortunately, while the 8087 NDP hardware and the IBM PC software both use the same basic approach to storing real numbers as described above, they do not use identical formats. This means that a real number entered from IBM BASIC or Pascal cannot be directly moved into the 8087 and used for computational purposes. Numbers must be transformed from IBM to 8087 format and then, after all computations are finished, converted back from 8087 to IBM format.

The differences between the two formats are in the way that the three fields of the real number are stored and the treatment that the binary exponent receives. For a 32-bit short-real number (the size used by BASIC and Pascal), both 8087 and IBM formats designate 1 bit for the sign, 8 bits for the exponent, and 23 bits for the significand. The IBM format places the 8-bit exponent in the first byte by itself, the sign bit in the first bit of the second byte, and the 23-bit significand in the remaining bits. This scheme makes manipulation of the exponent byte easy to do in software.

The 8087, concerned with maximizing the processing of these numbers in hardware, places the sign bit in the upper bit of the first byte, the exponent gets the remaining 7 bits in that byte and the upper bit in the second byte, with the significand getting the remaining 23 bits.

*[***Editor's Note:** Both real and integer numbers in Intel format are read from the byte with the highest address to the byte with the lowest address. Thus, given a 32-bit real number in bytes *n* through $n+3$, the "first" byte talked about in these paragraphs is byte $n+3$, the "second" byte is $n+2$, and so on. . . .**G. W.***]*

Thus, to move a number from IBM format to 8087 format, we must save the sign bit of the number (from bit 7 of the second byte), shift the first byte right one bit with the lowest bit being placed into the upper bit of the second byte, and then placing the sign bit into bit 7 of the first byte. Converting from 8087 to IBM reverses the operation.

Finally, converting between the IBM and 8087 formats requires changing the exponent field in a way called biasing*. The two formats are slightly different in their requirements. The differences lie once again in the fact that the IBM-format real numbers are set up to allow easy use from software and 8087-format numbers are optimized for hardware manipulation.*

The 8087 format biases the exponent by adding a bias value *to the true exponent. The size of the bias exponent depends on the type of real number being used: a short-real number adds a bias value of 127 (decimal), a long-real number uses 1023, and a temporary-real number uses 16,383.*

The IBM format uses a different biasing scheme, the end result of which is that the IBM format exponent is 2 greater than the 8087 format. To convert from the IBM to the 8087 format, subtract 2 from the exponent. Add 2 to the exponent to go from 8087 to IBM format. There is one exception to the conversion processes. The real number 0.0 is stored as all zeros in both formats.

Listing 2 contains two assembly-language routines that convert short-real numbers from IBM to 8087 format (C_IBM_8087) and vice versa (C_8087_IBM). These efficient conversion routines require less than 20 microseconds to convert a short-real number. Similar routines are easily implemented for long-real-number conversions (however, IBM's Pascal does not use double-precision real numbers).

In any user-application program, it is the user's responsibility to keep track of the current format of any number. Usually, the numbers need be converted only when they are input from the user and then again when they are output to the user. Most intermediate steps can leave the numbers in 8087 format.

CHK_CONC macro in M8087. Basically, this macro is called from CHOOSE_4 and INT_SIZE whenever any external variable reference is made by an 8087 operation. It includes a user-settable flag (named AUTOSYNC) that determines whether CHK_CONC will do anything or not.

If the AUTOSYNC flag is set (i.e., has a nonzero value), then any call to CHK_CONC will result in a WAIT instruction being inserted immediately *after* the 8087 instruction that accesses the external variable. This forces the 8088 to wait until the 8087 instruction is finished, thus ensuring exclusive access to the variable by the 8087. The AUTOSYNC flag is set by default and must be explicitly cleared (simply by inserting the line "AUTOSYNC = 0" anywhere in the assembly-language source code) to disable the forced concurrency.

If the user knows that no problem will exist between the 8088 CPU and the 8087, then the AUTOSYNC flag should be cleared. This saves both memory space (a WAIT instruction takes up a byte) and execution time and allows exploitation of the parallel processing capabilities of the 8088/8087 system.

Performance of M8087

So how well does M8087 work? Well, it works very well from every point of view except assembly time. After a little practice, the 8087 mnemonics become second nature (much as the standard 8088 assembly-language mnemonics). However, the lengthy macros that M8087 uses can significantly increase the time it takes to assemble an assembly-language file that uses 8087 mnemonics. But let me reiterate that this is a one-time cost that occurs only when you create the executable object-code file (which runs extremely fast).

I created several short utility programs needed to use the 8087 in the IBM PC. The first, explained in the text box "Interchanging Real-Value Formats" and given in listing 2, converts real-value numbers between the slightly different formats used by IBM software and the 8087.

Text continued on page 372
Listing on page 366

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```
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-------------------------------------
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    C) ANOVA
    D) TIME SERIES
    E) MULTIVAR

⟨ESC⟩) Exit to Master Menu

Choice–⟩[      ]
```

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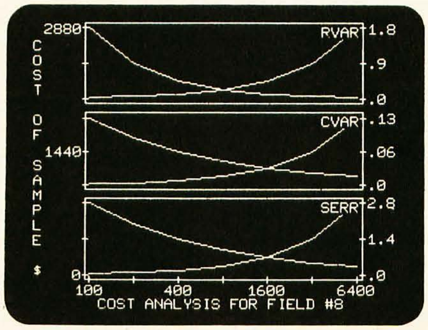

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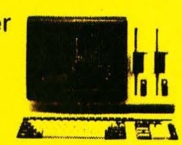

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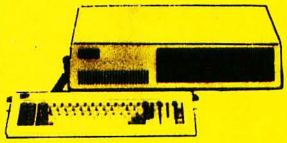

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Listing 2: *Two subroutines to convert floating-point numbers between IBM and 8087 internal formats.*

```
                        PAGE 88,132      ; Set page width to 132 columns
                        TITLE            - IBM/8087 Short-Real Conversion Routines

                        ASSUME CS:CODE
0000                    CODE SEGMENT
                        ;
                        ; This file can be assembled separately and then linked with any other
                        ; files that need the conversion routines
                        ;

                        PUBLIC C_IBM_8087
                        ;
                        ;       C_IBM_8087 - routine to convert a 'short-real number from IBM
                        ;                    to 8087 format
                        ;
                        ;       Inputs :     Register BP points to the 4-byte 'short-real'
                        ;                    value to be converted
                        ;
                        ;       Outputs:     Converted value is written over original
                        ;                    AX register contents destroyed
                        ;
0000                    C_IBM_8087      PROC    FAR

                        ; Real numbers are stored least significant byte at lowest addr.
0000  8B 46 02                  mov     ax,[bp+2]       ; get most significant 2-bytes
0003  3D 0000                   cmp     ax,0            ; Test for "zero" value
0006  75 06                     jne     CONTIBM         ; Skip if not zero and continue conversion
0008  83 7E 00 00               cmp     word ptr [bp],0 ; Check second word for zero
000C  74 0D                     je      EXITIBM         ; If all 4 bytes are zero, no conversion
000E                    CONTIBM:
000E  FE CC                     dec     ah              ; subtract two from exponent
0010  FE CC                     dec     ah              ;
0012  D0 D0                     rcl     al,1            ; rotate sign bit into 8088 carry field
0014  D0 DC                     rcr     ah,1            ; rotate sign bit into upper byte for 8087
                                                        ; (also rotates lowest bit into carry field)
0016  D0 D8                     rcr     al,1            ; rotate lowest bit of exponent into lower byte
0018  89 46 02                  mov     [bp+2],ax       ; save new value back on top of original
001B                    EXITIBM:
001B  CB                        ret
001C                    C_IBM_8087      ENDP


                        PUBLIC C_8087_IBM
                        ;
                        ;       C_8087_IBM - routine to convert a 'short-real number from 8087
                        ;                    to IBM format
                        ;
                        ;       Inputs :     Register BP points to the 4-byte 'short-real'
                        ;                    value to be converted
                        ;
                        ;       Outputs:     Converted value is written over original
                        ;                    AX register contents destroyed
                        ;
001C                    C_8087_IBM      PROC    FAR

001C  8B 46 02                  mov     ax,[bp+2]       ; get most significant 2-bytes
001F  3D 0000                   cmp     ax,0            ; Test for "zero" value
0022  75 06                     jne     CONT8087        ; Skip if not zero and continue conversion
0024  83 7E 00 00               cmp     word ptr [bp],0 ; Check second word for zero
0028  74 0D                     je      EXIT8087        ; If all 4 bytes are zero, no conversion
002A                    CONT8087:
002A  D0 D0                     rcl     al,1            ; rotate lowest exponent bit into carry field
002C  D0 D4                     rcl     ah,1            ; move lowest exponent bit into upper byte and
                                                        ;   move sign bit into carry field at same time
002E  D0 D8                     rcr     al,1            ; rotate sign bit into lower byte as needed
0030  FE C4                     inc     ah              ; add two to exponent
0032  FE C4                     inc     ah              ;
0034  89 46 02                  mov     [bp+2],ax       ; save new value back on top of original
0037                    EXIT8087:
0037  CB                        ret
0038                    C_8087_IBM      ENDP

0039                    CODE ENDS
                        END
```

Listing 3: *Four 8087 status-word utility programs.*

```
                        PAGE 86,132
                        TITLE           - 8087 Utility Programs

                        ; Now, lets pull in the 8087 software support macros

                        ENDIF

                        ASSUME CS:CODE, DS:CODE

0000                    CODE SEGMENT

                        ;
                        ; FUNCTION CHK87 : INTEGER;
                        ;
                        ;       This function executes a FSTSW macro to get condition codes
                        ;       from 8087.  Assumes user loaded "B" unto top of stack and
                        ;       then either loaded "A" and compared/tested or else compared/tested
                        ;       "A" from memory (ie. FCOMP A).
                        ;                       Returns:
                        ;                               0 - A = B
                        ;                               1 - A > B
                        ;                               2 - A < B
                        ;                               3 - No Order between A and B
                        ;
                        ;                       Register AX is destroyed
                        ;
                        ;

                        PUBLIC CHK87

0000                    CHK87 PROC FAR

0000  50                        PUSH    AX              ; Status will be stored in this location
0001  55                        PUSH    BP              ; Need to get address to stack
0002  8B EC                     MOV     BP,SP           ; Will use BP as address for store
                                FSTSW   [BP+2]          ; Get status of top of stack in memory
0004  9B                + WAIT
0005  DD 7E 02          + ESC 2FH,[BP+2]
0008  5D                        POP     BP              ; Restore BP address
0009  58                        POP     AX              ; Moves status into register AX
000A  9E                        SAHF                    ; LOAD CONDITION CODES INTO CPU FLAGS
                                ;USE CONDITIONAL JUMPS TO DETERMINE ORDERING OF A AND B
000B  72 0A                     JB      A_LESS_OR_UNORDERED
                                                        ; OTHERWISE CF = C0 = 0
000D  75 04                     JNE     A_GREATER       ; JUMP IF A > B

000F                    A_EQUAL:
000F  B0 00                     MOV     AL,0            ;
0011  EB 0C                     JMP     SHORT EXIT_CHK  ;

0013                    A_GREATER:
0013  B0 01                     MOV     AL,1            ;
0015  EB 08                     JMP     SHORT EXIT_CHK  ;

0017                    A_LESS_OR_UNORDERED:
0017  75 04                     JNE     A_LESS          ;

0019                    A_B_UNORDERED:
0019  B0 03                     MOV     AL,3            ;
001B  EB 02                     JMP     SHORT EXIT_CHK  ;

001D                    A_LESS:
001D  B0 02                     MOV     AL,2            ;

001F                    EXIT_CHK:
001F  B4 00                     MOV     AH,0            ; Upper byte of return value is zero
0021  CB                        RET

0022                    CHK87 ENDP

                        PAGE

                        ;
                        ; FUNCTION EXAM87 : INTEGER;
                        ;
                        ;       This function executes a FXAM 8087 instruction which allows
                        ;       user to determine whether the value on the top of the 8087
                        ;       stack is positive or negative and either NAN (Not-A-Number),
                        ;       unnormal, denormal, normal or zero.
                        ;
                        ;               Inputs  :       None
                        ;
                        ;               Outputs :       Returns value 0 - 15 as function
                        ;
                        ;                                0 : + Unnormal
                        ;                                1 : + NAN
                        ;                                2 : - Unnormal
                        ;                                3 : - NAN
                        ;                                4 : + Normal
                        ;                                5 : + Infinity
                        ;                                6 : - Normal
                        ;                                7 : - Infinity
                        ;                                8 : + Zero
                        ;                                9 :   Empty
                        ;                               10 : - Zero
                        ;                               11 :   Empty
                        ;                               12 : + Denormal
                        ;                               13 :   Empty
                        ;                               14 : - Denormal
                        ;                               15 :   Empty
                        ;
```

Listing 3 continued on page 368

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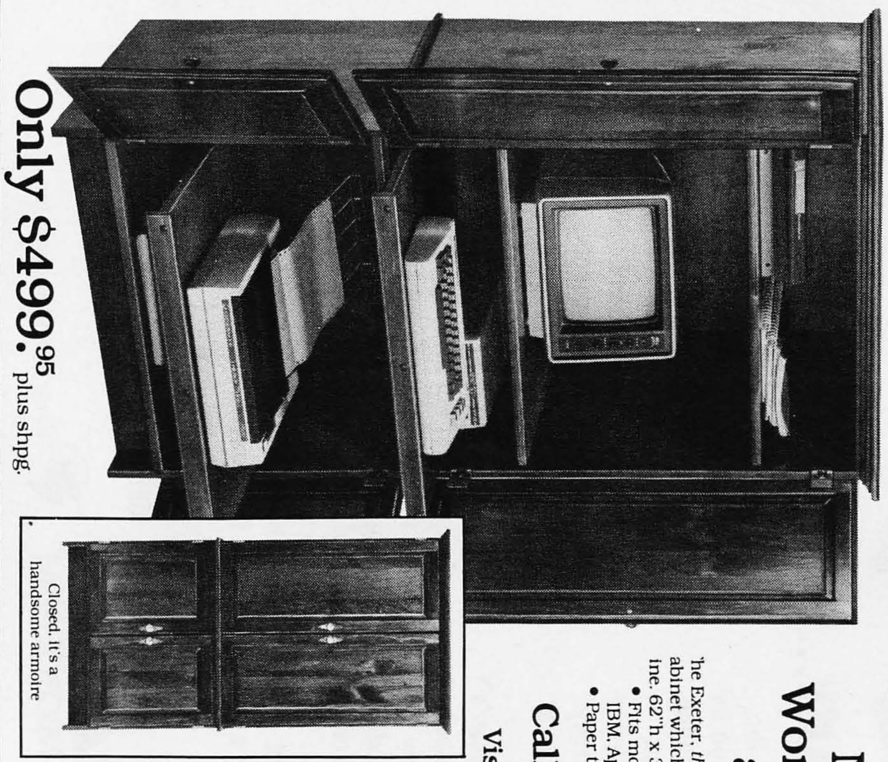
Listing 3 continued:

```
                    PUBLIC EXAM87

0022                EXAM87 PROC FAR

                          FXAM                ; Execute EXAM operation on TOS
0022 9B             + WAIT
0023 D9 E5          + ESC 0CH,BP
0025 50                   PUSH    AX          ; Status will be stored in this location
0026 55                   PUSH    BP          ; Need to get address to stack
0027 8B EC                MOV     BP,SP       ; Will use BP as address for store
                          FSTSW   [BP+2]      ; Get status of top of stack in memory
0029 9B             + WAIT
002A DD 7E 02       + ESC 2FH,[BP+2]
002D 5D                   POP     BP          ; Restore BP address
002E 58                   POP     AX          ; Moves status into register AX
002F 8A C4                MOV     AL,AH       ; Put C3 bit into bit 14
0031 25 4007              AND     AX,4007H    ; Clear out all but C0 to C3 bits
0034 D0 EC                SHR     AH,1        ; Shift C3 bit down to bit 11
0036 D0 EC                SHR     AH,1        ;
0038 D0 EC                SHR     AH,1        ;
003A 0A C4                OR      AL,AH       ; Put C3 bit into bit 3
003C B4 00                MOV     AH,0        ; Now AX contains proper status value
003E CB                   RET

003F                EXAM87 ENDP

                    PAGE

                    ;
                    ; FUNCTION GETST : INTEGER;
                    ;
                    ;       This function gets current STACK TOP POINTER value from status
                    ;       word and returns it to user
                    ;
                    ;              Inputs  :      None
                    ;
                    ;              Outputs :      Returns value 0 - 7 as function
                    ;
                    PUBLIC GETST

003F                GETST PROC FAR

003F 50                   PUSH    AX          ; Status will be stored in this location
0040 55                   PUSH    BP          ; Need to get address to stack
0041 8B EC                MOV     BP,SP       ; Will use BP as address for store
                          FSTSW   [BP+2]      ; Get status of top of stack in memory
0043 9B             + WAIT
0044 DD 7E 02       + ESC 2FH,[BP+2]
0047 5D                   POP     BP          ; Restore BP address
0048 58                   POP     AX          ; Moves status into register AX
0049 8A C4                MOV     AL,AH       ; Get stack top value in AH
004B 25 0038              AND     AX,0038h    ; Mask out all but stack count
004E D0 E8                SHR     AL,1        ; Shift count to low three bits
0050 D0 E8                SHR     AL,1        ;
0052 D0 E8                SHR     AL,1        ;
0054 CB                   RET

0055                GETST ENDP


                    ;
                    ; FUNCTION STATUS : INTEGER;
                    ;
                    ;       This function gets current status bits from status
                    ;       word and returns it to user
                    ;
                    ;              Inputs  :      None
                    ;
                    ;              Outputs :      Returns value 0 - 255 as function
                    ;
                    PUBLIC STATUS

0055                STATUS PROC FAR

0055 50                   PUSH    AX          ; Status will be stored in this location
0056 55                   PUSH    BP          ; Need to get address to stack
0057 8B EC                MOV     BP,SP       ; Will use BP as address for store
                          FSTSW   [BP+2]      ; Get status in memory
0059 9B             + WAIT
005A DD 7E 02       + ESC 2FH,[BP+2]
005D 5D                   POP     BP          ; Restore BP address
005E 58                   POP     AX          ; Moves status into register AX
005F B4 00                MOV     AH,0        ; Clear out all but status bits
0061 CB                   RET

0062                STATUS ENDP

0062                CODE ENDS
                    END
```

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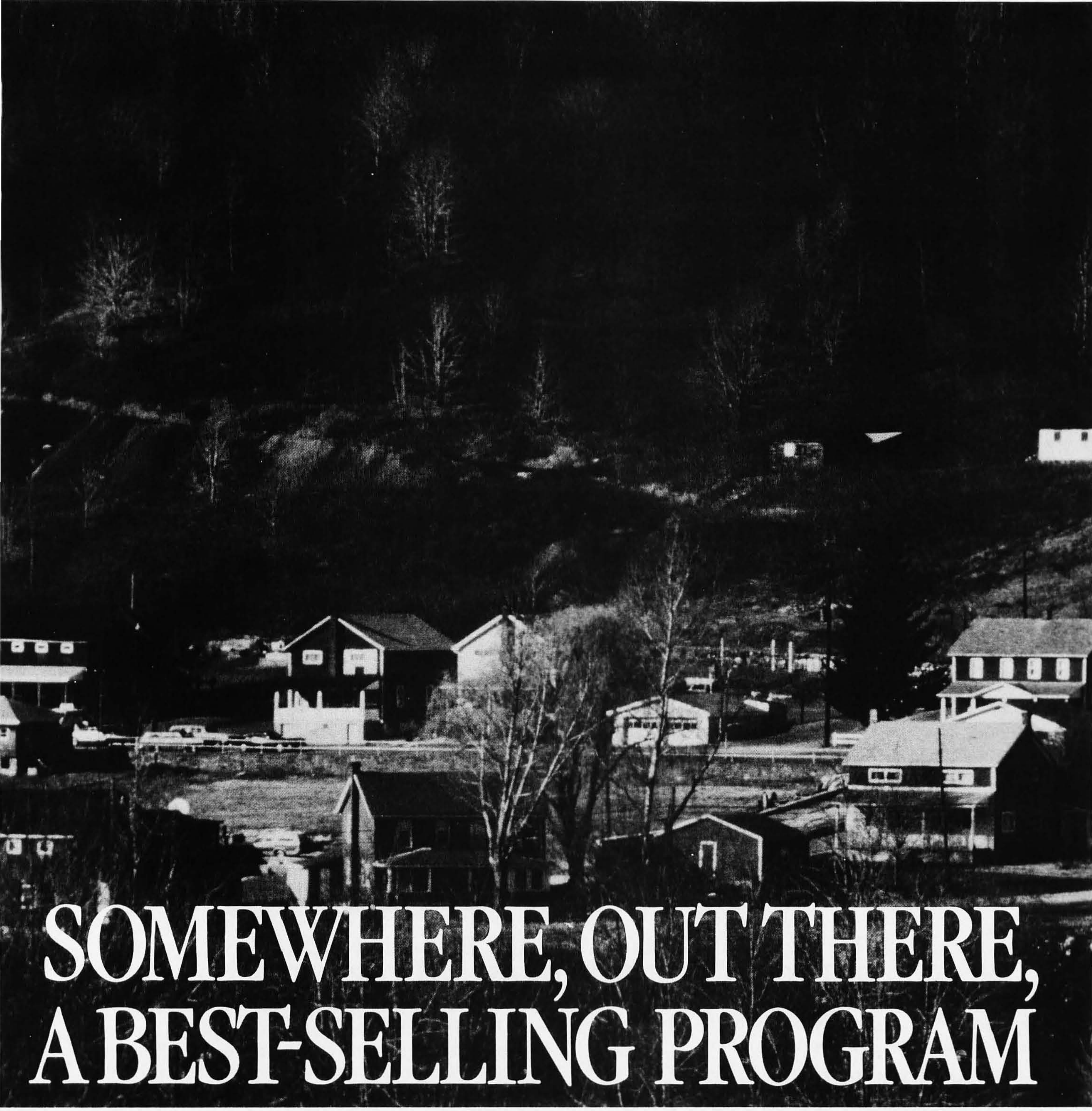

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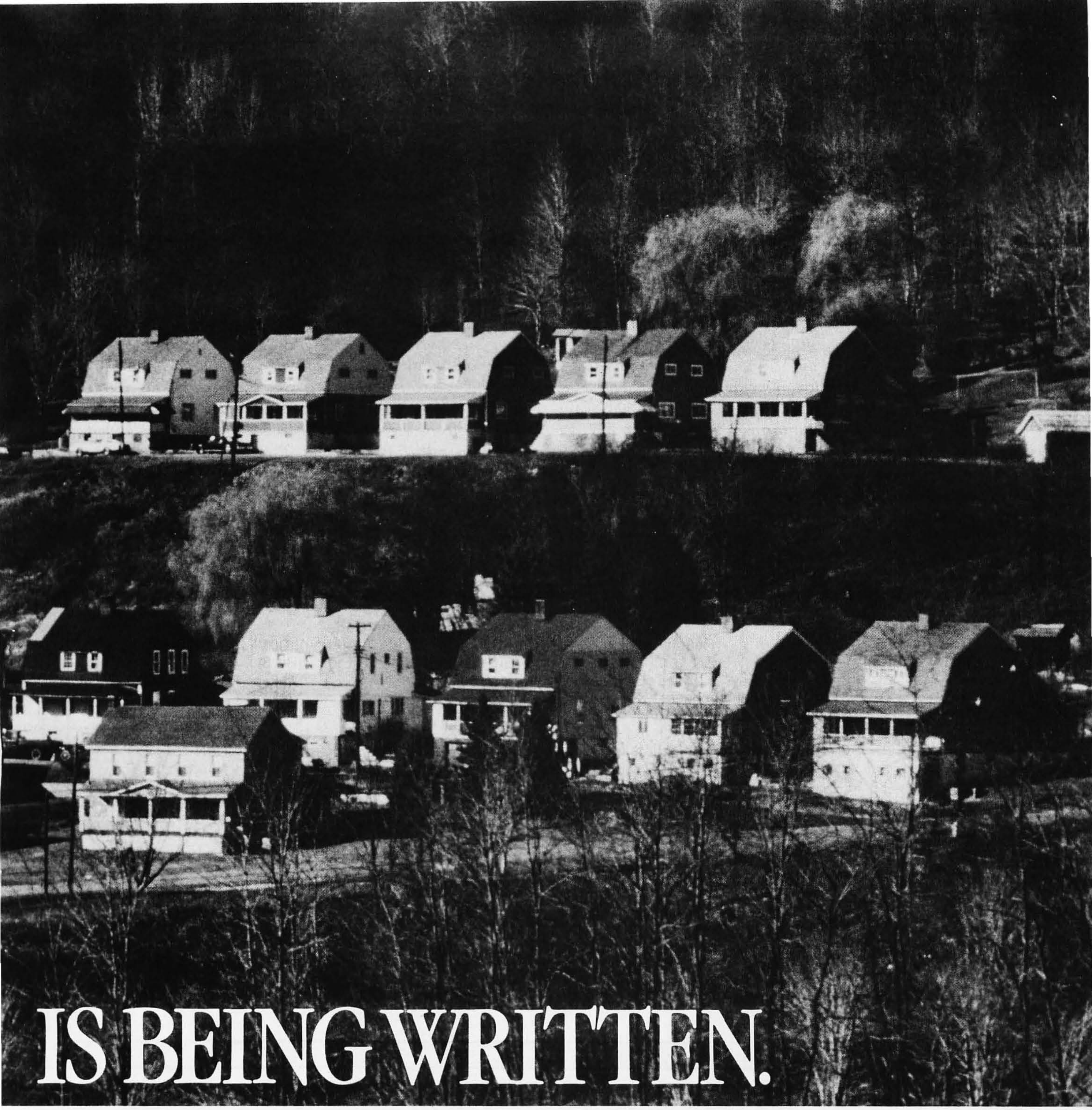

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8087 Status-Word Utilities

The 8087 comparison operations look at the top stack element within the 8087 and compare it with some other operand or test it (i.e., implicitly compare the top-of-stack with 0.0). The 8087 has an internal status word *that can be accessed (via the FSTSW "store status word" instruction) by the 8088 CPU to determine the results of the comparison operations. The 8087 status word reflects the overall condition of the chip.*

It should be made clear at this point that the 8087 NDP and 8088 CPU do not *share registers. You cannot move the contents of an 8088 register directly to the 8087 stack or vice versa. To move a value from an internal 8088 register (perhaps containing a 16-bit word-integer), you must move that value into some temporary location in memory and then load it into the 8087. To examine the internal status of the 8087, you must store the status word into memory using the FSTSW operation, then move it into the 8088 CPU internal registers for testing.*

The main use of the status word is for conditional branching (i.e., to test a register or registers and branch to a certain code depending on the value of the register or the comparison of two registers). Table 2 shows the different interpretations of the 8087 condition-code bits of the status word for the three comparison instructions; NAN means "not a (valid) number." Condition-code bits C0 through C3 are bits 8, 9, 10, and 14 of the status word.

Listing 3 contains four subroutines that provide access to the 8087 status word and return to the user some indication of the internal state of the 8087. These routines are a great help in debugging programs during software development because they provide a "peek" into the 8087.

The first of the four routines, CHK87, is designed to be executed immediately after an 8087 test or comparison operation is executed (see FTST and the FCOM variations of instructions in table 1). This routine will return an indication of whether the comparison/test returned "equal to," "greater than," "less than," or "no order." The condition-code bits C0 and C3 from the 8087 status word are used as defined in tables 2a and 2b to determine these results.

The EXAM87 routine executes the 8087 FXAM instruction, which examines the top stack element. The 4 condition-code bits (C0 to C3) in the status word are set according to the rules set out in table 2c. EXAM87 returns the value (0 to 15) under this interpretation of the condition codes.

(2a)

C3 (Bit 14)	C0 (Bit 8)	Result
0	0	ST is positive and nonzero
0	1	ST is negative and nonzero
1	0	ST is zero (+ or −)
1	1	ST is not comparable (i.e., it is a NAN or projective ∞)

(2b)

C3 (Bit 14)	C0 (Bit 8)	Order
0	0	ST > source
0	1	ST < source
1	0	ST = source
1	1	ST?source

(2c)

Condition Code C3 (Bit 14)	C2 (Bit 10)	C1 (Bit 9)	C0 (Bit 8)	Interpretation
0	0	0	0	+ Unnormal
0	0	0	1	+ NAN
0	0	1	0	− Unnormal
0	0	1	1	− NAN
0	1	0	0	+ Normal
0	1	0	1	+ ∞
0	1	1	0	− Normal
0	1	1	1	− ∞
1	0	0	0	+ 0
1	0	0	1	Empty
1	0	1	0	− 0
1	0	1	1	Empty
1	1	0	0	+ Denormal
1	1	0	1	Empty
1	1	1	0	− Denormal
1	1	1	1	Empty

Table 2: *The 8087 condition codes and their interpretations. Each bit is described in terms of its position within the 8087 status word.*

Text continued from page 362:

The rest, explained in the text box "8087 Status-Word Utilities" and given in listing 3, give four needed utility routines that let the 8088 CPU interact with the 8087 status register.

Some things can be done to M8087 to speed up its use. First, avoid entering all the comments found in listing 1 into the M8087.MAC file. This saves both disk space and a great deal of assembly time (comment lines slow down the assembler). I have included fairly detailed comments in listing 1 for the reader's sake. The version I actually use has had all the comments removed for maximum performance.

Another way to speed up M8087 is to remove the lowercase support features included in the CHECK_ST, CHOOSE_4, and INT_SIZE macros. For every operand memory type and "ST" use, these macros check for lowercase and uppercase versions of the same string. This is a nice feature, but it does cost in assembly time.

Implementing the above suggestions cuts the disk file size of M8087 from around 20K bytes to 6K bytes. The speedup of the reduced file is dependent on the percentage of instructions in the program that are 8087 operations, but the above modifications can cut assembly time by as much as half.

The IBM Macro Assembler recognizes the "real" constant type. It lets you include a value in decimal scientific

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More on the 8087

For more information on the 8087 and how it works, see the text boxes in this article, the article "The Intel 8087 Numerics Processor Extension" (April 1983 BYTE, page 154—in particular, see the text box on 8087 binary arithmetic on pages 174 and 175), and Intel Corporation's Numerics Supplement to the 8086 Family User's Guide. *For more information, contact the source below..*

M8087 on Disk

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notation such as "27.24E−2" in your program. It assembles this into a 32-bit IBM-format binary real number. This is a handy feature and, when used with the conversion routines from listing 1, can be used in 8087-based computations.

The main task remaining for an assembly-language programmer wishing to use the 8087 is to write a couple of routines that will convert real numbers into their ASCII (American National Standard Code for Information Interchange) equivalents (and vice versa). This will let you enter and display real variables from an assembly-language program. An Intel application note (#AP-113, "Getting Started With the Numeric Data Processor") has assembly-language routines to do these and other tasks.

Final Notes

The bottom line to M8087 is "Is it worth the cost in assembly time?" For myself the answer is a hearty *yes*. If using it increased the running time of a program, my answer would be different. But a slowdown in assembly time is a small price to pay for not having to hand-assemble each 8087 instruction into its escape sequence.

We have seen what the Intel 8087 NDP is, what it can do, how it fits into the IBM Personal Computer, and how we can provide software support for the assembly-language programmer using the 8087 in the IBM PC. Next month, we will see how to provide higher-level support so that Pascal users can access the 8087. ■

Acknowledgment

I would like to thank Brian Van Herp of Intel in Indianapolis for his assistance.

Tim Field (909 North San Antonio Rd., Los Altos, CA 94022) has a master's degree in computer science from Purdue University. His experience includes several years' work at Digital Equipment Corp.

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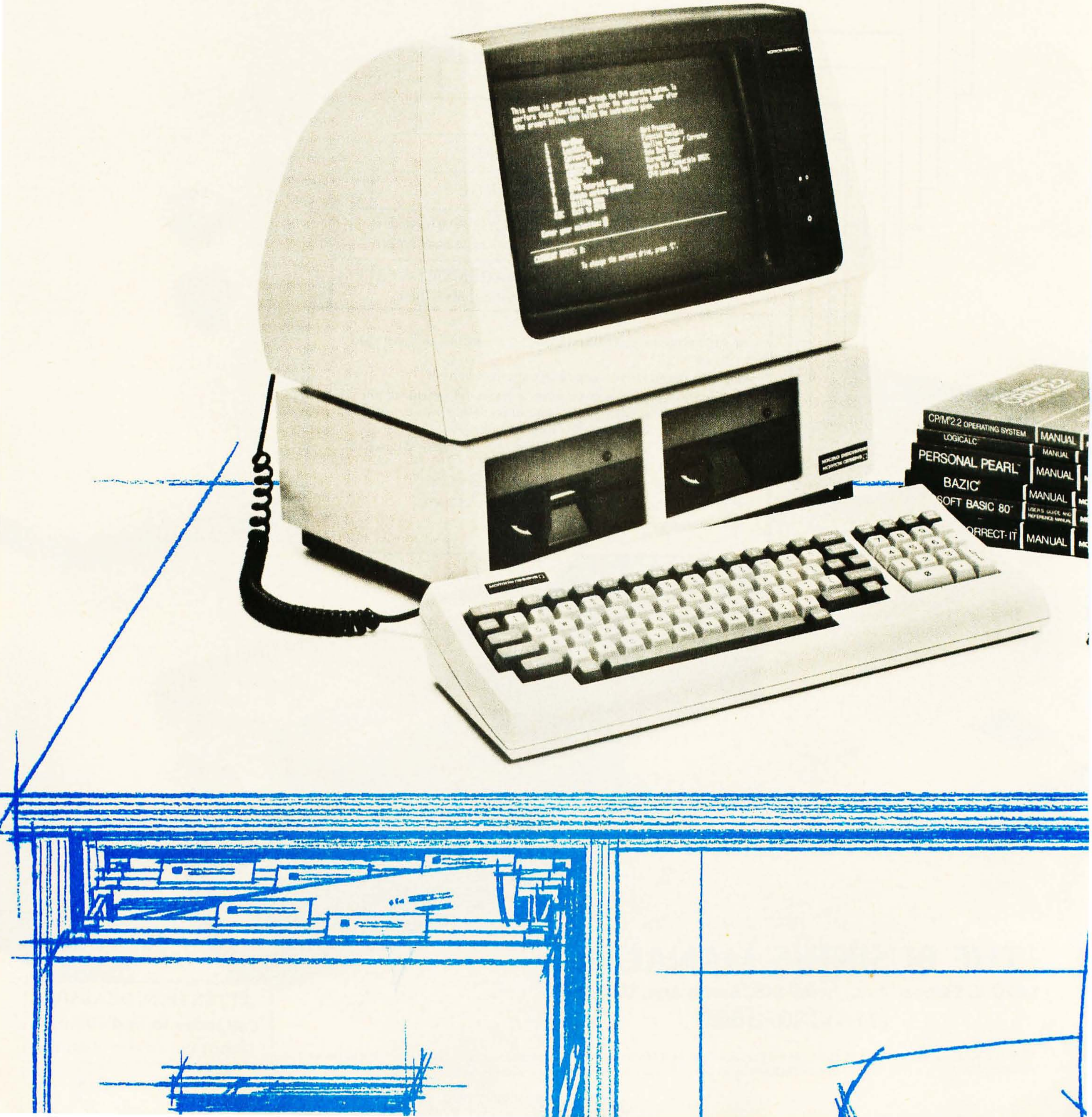

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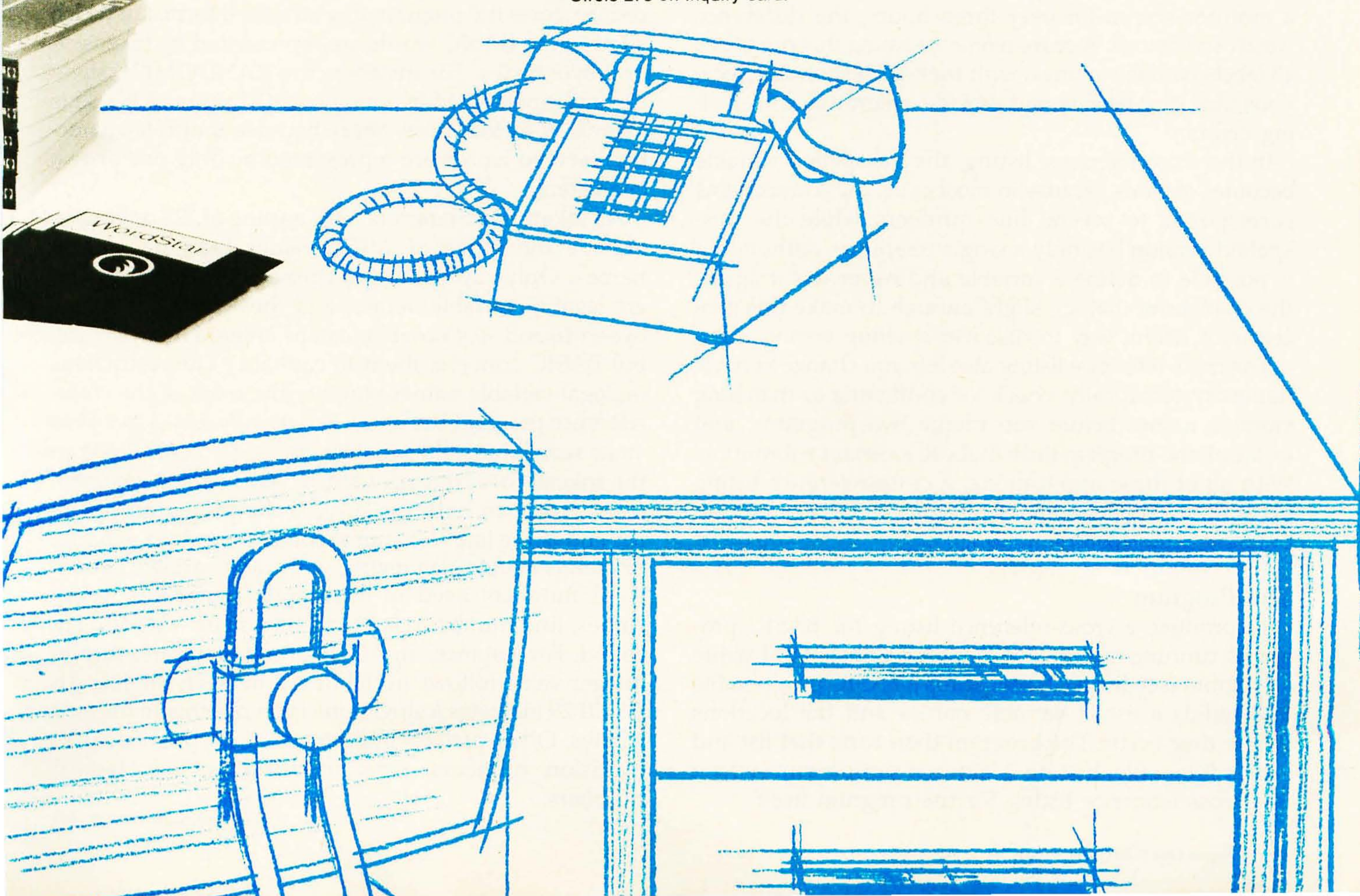


Cross-Reference Utility for IBM PC BASIC Programs

by James A. Folts

After struggling to debug a BASIC program, I finally discovered that my problem was a misspelled variable name in one line. To BASIC, CLRCSR and CLRSCR are as different as black and white. To me, after staring at a monitor screen for over three hours, the difference wasn't so obvious. A cross-reference listing that organizes all labels (variable names) with their corresponding locations (line numbers) would provide a handy clue to spelling errors.

In the cross-reference listing, the misspelled variable becomes obvious because in most cases the correct name corresponds to several line numbers while the misspelled version has only a single reference. Although it is possible to define a variable and never use it again, the chances of that are slight enough to make this procedure a useful way to discover spelling errors.

The cross-reference listing also lets you change variable names systematically, check for conflicting or matching variable names before you merge two programs, and locate all the program lines that call a certain subroutine. With all of these applications, a cross-reference listing becomes a valuable tool for program development, debugging, and documentation.

The Program

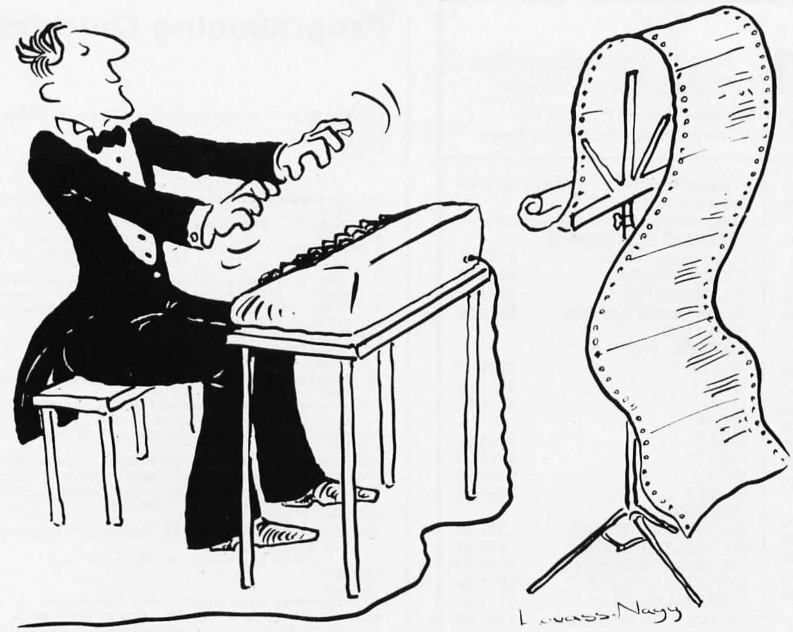
To produce a cross-reference listing for BASIC programs running on the IBM Personal Computer, I wrote a program (see listing 1) that scans a BASIC program file and builds a list of variable names and the locations where they occur. The program then sorts that list and writes it to a file. Listing 2 shows a sample run, which is a cross-reference listing for the program itself.

The program expects a standard BASIC program file, that is, one saved without the special A (ASCII—American National Standard Code for Information Interchange) or P (protect) options. The standard save procedure stores the program in a tokenized format in which all reserved BASIC words are represented by tokens, 1- or 2-byte codes. For instance, the RANDOMIZE statement is represented by a single ASCII value of 185. This tokenized format saves space because multiple-character reserved words are represented by only one or two characters.

All tokenized characters have a value of 128 or greater, outside the range of ASCII values legal in variable names. Only capital letters, numerals, and the period are legal in variable names, and these have values between 46 and 90. (Variables can be entered in lowercase, but BASIC converts them to capitals.) The restrictions on legal variable names simplify the work of the cross-reference program because it can usually just skip tokens in its search for valid variable names. Two exceptions are the tokens for a remark (ASCII 143) or data statement (ASCII 132). In both these cases the program skips to the end of the line so as not to confuse words in remarks, or literals in data statements, with valid variable names.

All numbers used in a program—constants, initial values, line-number references, and so on—are also encoded. For instance, an ASCII 28 code indicates that an integer value follows in the next 2 bytes in the file. An ASCII 29 indicates a single-precision number in the next 4 bytes. Other prefixes indicate various types of double-precision numbers, octal numbers, or hexadecimal numbers.

Text continued on page 384



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Programming Quickies

Listing 1: *Source code for cross-reference utility, written in IBM PC BASIC.*

```
1    REM*********************************************************************
2    REM*                                                                   *
3    REM*      CROSS-REFERENCE LISTING UTILITY FOR BASIC PROGRAMS           *
4    REM*                FOR THE IBM PERSONAL COMPUTER                      *
5    REM*                       by James A. Folts                           *
6    REM*                                                                   *
7    REM*  This program reads a tokenized BASIC program file, finds and sorts *
8    REM*    all variable names and line references, and lists them on a disk *
9    REM*    file. Each name and line reference is cross-referenced to the  *
10   REM*    line where it appears.                                         *
11   REM*                                                                   *
12   REM*  IBM PC BASIC                                        JUNE 26, 1982 *
13   REM*                                                                   *
14   REM*********************************************************************
15   REM
100 REM************* INITIALIZATION AND DEFINITIONS ***************************
110 DIM LABEL$(500), LINE.REF%(500), C$(128)
120 LABEL.NUMBER = 0 : FALSE=0 : TRUE=NOT FALSE : POINTER=129
130 REM
200 REM************* GET FILE NAME OF BASIC PROGRAM ***************************
210 CLS : KEY OFF : PRINT "BASIC CROSS REFERENCE GENERATOR" : PRINT
220 INPUT "ENTER FILE NAME: ", FILENAME$ : PRINT
230 OPEN FILENAME$ AS #1 LEN=128
240 REM
300 REM******************** INITIALIZE INPUT FILE ***************************
310 FOR I=1 TO 128                              'set up file buffer as an array
320     FIELD #1, (I-1) AS X$, 1 AS C$(I)       'of 128 single characters
330 NEXT I
340 REM
400 REM****** READ FIRST THREE CHARACTERS OF BASIC PROGRAM FILE ***************
420 GOSUB 7000 : IF C<>255 THEN PRINT "NOT A TOKENIZED PROGRAM FILE" : END
430 GOSUB 4000        'subroutine to get value for BASIC's offset address
440 REM
500 REM******* CONTINUE READING THE FILE: FILL ARRAYS LABEL$ AND LINE% ********
510 REM*************** WITH VARIABLE NAMES AND LINE NUMBERS ********************
520 WHILE ADR<>0   'ADR=0 indicates end of program file
530     REM****** GET LINE NUMBER (A TWO-BYTE INTEGER VALUE) ************
540     GOSUB 7000   : LOW.BYTE = C
550     GOSUB 7000   : HIGH.BYTE = C
560     LINE.NO% = (HIGH.BYTE * 256) + LOW.BYTE
570     LOCATE 10,1 : PRINT "PROCESSING LINE NUMBER"; LINE.NO%;
580     GOSUB 7000   'get first character after line number
590     REM****** NOW READ REST OF LINE ***********************************
600     WHILE C<>0       'C=0 indicates end of line
610         IF C=143 OR C=132 THEN WHILE C<>0 : GOSUB 7000 : WEND : GOTO 720
                                  'remark or data statement--skip to end of line
620         IF C=209 THEN LABEL.NUMBER=LABEL.NUMBER+1 : LABEL$(LABEL.NUMBER)=
                   "FN" : GOSUB 5030 : GOTO 720    'get user-def function name
630         IF C>127 GOTO 710                 'skip any other tokens
640         IF (C>64 AND C<91) THEN GOSUB 5000 : GOTO 720    'get variable name
650         IF C=14 THEN GOSUB 6000 : GOTO 720        'get line number reference
660         IF C=34 THEN GOSUB 7000 : WHILE C<>34 AND C<>0 : GOSUB 7000 :
                   WEND : IF C=0 GOTO 720 : GOTO 710     'skip string constant
670         IF C=15 THEN GOSUB 7000 : GOTO 710          'skip one-byte number
680         IF (C>10 AND C<14) OR C=28 THEN GOSUB 7000 : GOSUB 7000 : GOTO 710
                                            'skip two-byte number that follows
690         IF C=29 THEN FOR I=1 TO 4 : GOSUB 7000 : NEXT I : GOTO 710
                                            'skip four-byte number
700         IF C=31 THEN FOR I=1 TO 8 : GOSUB 7000 : NEXT I : GOTO 710
                                            'skip 8-byte number
710         GOSUB 7000
720     WEND
730     GOSUB 4000   'begin new line; get next value for offset address
740 WEND
750 REM
800 REM*********** SORT LABELS AND LINE NUMBERS ******************************
810 LOCATE 12,1 : PRINT  "PROCESSING COMPLETE . . ."
820 PASS=0
830 G%=LABEL.NUMBER
840 PASSES=INT(LOG(G%)/LOG(2))
850 WHILE G%>1
860     PASS=PASS+1
870     LOCATE 14,1:PRINT "SORTING: PASS ";PASS;" OF ";PASSES;" PASSES";
880     SORTED=FALSE
890     G%=G%\2
900     WHILE NOT SORTED
910         SORTED=TRUE
920         FOR I%=1 TO LABEL.NUMBER-G%
930             IG%=I%+G%
940             IF LABEL$(I%)<LABEL$(IG%) GOTO 1030
950             IF LABEL$(I%)=LABEL$(IG%) GOTO 1000
960                 SWAP LABEL$(I%),LABEL$(IG%)
970                 SWAP LINE.REF%(I%),LINE.REF%(IG%)
980                 SORTED=FALSE
990                 GOTO 1030
1000            IF LINE.REF%(I%)=<LINE.REF%(IG%) GOTO 1030
1010                SWAP LINE.REF%(I%),LINE.REF%(IG%)
1020                SORTED=FALSE
1030        NEXT I%
1040    WEND
1050 WEND
1060 LOCATE 16,1 : PRINT "SORT COMPLETE . . . WRITING FILE" : PRINT
1070 REM
2000 REM************* CREATE FILE NAME FOR LISTING ***************************
2010 PERPOS = INSTR(FILENAME$,".")          'find position of period in filename
2020 IF PERPOS=0 THEN PERPOS=LEN(FILENAME$)+1   'if no period, pretend there is
2030 LISTFILE$ = LEFT$(FILENAME$,PERPOS-1)+".CRF"  'create filename for listing
2040 OPEN LISTFILE$ FOR OUTPUT AS #2            'open sequential file for listing
2050 PRINT #2,"CROSS REFERENCE LISTING FOR PROGRAM FILE: ";FILENAME$
2060 PRINT #2,"CREATED AT "; TIME$; " ON "; DATE$
2070 REM
3000 REM************ WRITE CROSS REFERENCE TABLE TO FILE **********************
3010 I = 1 : PRINT #2,                                  '* NOTE FOR LINE 3070:
3020 WHILE I =< LABEL.NUMBER                            '* N>3 gives 40 col
3030     PRINT #2, : PRINT #2, LABEL$(I); TAB(18);      '* N>8 gives 80 col
3040     CURRENT.LABEL$ = LABEL$(I) : N=1               '* N>16 gives 132 col
3050     WHILE LABEL$(I) = CURRENT.LABEL$               '**********************
3060         PRINT #2, USING "#####  "; LINE.REF%(I);
3070         I=I+1 : N=N+1 : IF N>8 THEN PRINT #2, : PRINT #2, TAB(18); : N=1
3080     WEND
3090     PRINT #2,  'begin new line
3100 WEND
3110 PRINT #2, : KEY ON : BEEP : END
3120 REM
4000 REM******* SUBROUTINE TO OBTAIN BASIC'S OFFSET ADDRESS FOR THIS LINE*****
4010 GOSUB 7000 : LOW.BYTE = C
4020 GOSUB 7000 : HIGH.BYTE = C
4030 ADR = HIGH.BYTE + LOW.BYTE       'not really correct, but address is only of
4040 RETURN                           'interest when zero, so this will do
4050 REM
5000 REM********* SUBROUTINE TO GET VARIABLE NAME ****************************
5010 LABEL.NUMBER = LABEL.NUMBER + 1
```

Listing 1 continued on page 382

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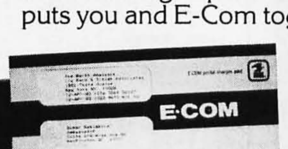

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Listing 1 continued:

```
5020 LABEL$(LABEL.NUMBER) = CHR$(C)      'put first character in label
5030 GOSUB 7000        'get second character
5040 WHILE (C>47 AND C<58) OR (C>64 AND C<91) OR C=46    'add legal characters:
                                   capital letters, numerals and the period
5050    LABEL$(LABEL.NUMBER) = LABEL$(LABEL.NUMBER) + CHR$(C)
5060    GOSUB 7000
5070 WEND
5080 IF (C>34 AND C<38) OR C=33 THEN LABEL$(LABEL.NUMBER)=LABEL$(LABEL.NUMBER)+
        +CHR$(C) : GOSUB 7000    'get variable type symbol if any
5090 WHILE C=32 : GOSUB 7000 : WEND    'skip over any blanks
5100 IF C=40 THEN LABEL$(LABEL.NUMBER)=LABEL$(LABEL.NUMBER)+"(SUB)": GOSUB 7000
                                'identify as a subscripted variable if it is
5110 LINE.REF%(LABEL.NUMBER) = LINE.NO%   'store current line number where this
                                   label appears
5120 RETURN
5130 REM
6000 REM********** SUBROUTINE TO GET LINE NUMBER REFERENCE ********************
6010 LABEL.NUMBER = LABEL.NUMBER + 1
6020 LINE.REF%(LABEL.NUMBER) = LINE.NO%
6030 GOSUB 7000 : LOW.BYTE = C
6040 GOSUB 7000 : HIGH.BYTE = C
6050 LABEL$(LABEL.NUMBER) = SPACE$(5)
6060 RSET LABEL$(LABEL.NUMBER) = STR$((HIGH.BYTE*256)+LOW.BYTE)
6070 GOSUB 7000
6080 RETURN
6090 REM
7000 REM**** SUBROUTINE TO GET ASCII VALUE FOR NEXT CHARACTER (C) *************
7010 IF POINTER < 128 GOTO 7040
7020 GET #1      'refill buffer
7030 POINTER=0  'and reset pointer
7040 POINTER = POINTER + 1
7050 C = ASC(C$(POINTER))    'get next character ASCII value
7060 RETURN
```

Listing 2: *Sample output from the cross-reference program.*

```
CROSS REFERENCE LISTING FOR PROGRAM FILE: DECODE.O
CREATED AT 19:22:59 ON 06-26-1982

 710            630   660   670   680   690   700

 720            610   620   640   650   660

 1000           950

 1030           940   990  1000

 4000           430   730

 5000           640

 5030           620

 6000           650

 7000           420   540   550   580   610   660   660   670
                680   680   690   700   710  4010  4020  5030
               5060  5080  5090  5100  6030  6040  6070

 7040          7010

ADR             520  4030

AS              230   320   320  2040

C               420   540   550   600   610   610   610   620
                630   640   640   650   660   660   660   660
                670   680   680   680   690   700  4010  4020
               5020  5040  5040  5040  5040  5040  5050  5080
               5080  5080  5080  5090  5100  6030  6040  7050

C$(SUB)         110   320  7050

CURRENT.LABEL$ 3040  3050

FALSE           120   120   880   980  1020

FILENAME$       220   230  2010  2020  2030  2050

G%              830   840   850   890   890   920   930

HIGH.BYTE       550   560  4020  4030  6040  6060

I               310   320   320   330   690   690   700   700
               3010  3020  3030  3040  3050  3060  3070  3070

I%              920   930   940   950   960   970  1000  1010
               1030

IG%             930   940   950   960   970  1000  1010

LABEL$(SUB)     110   620   940   940   950   950   960   960
               3030  3040  3050  5020  5050  5050  5080  5080
               5100  5100  6050  6060

LABEL.NUMBER    120   620   620   620   830   920  3020  5010
               5010  5020  5050  5050  5080  5080  5100  5100
               5110  6010  6010  6020  6050  6060

LINE.NO%        560   570  5110  6020

LINE.REF%(SUB)  110   970   970  1000  1000  1010  1010  3060
               5110  6020

LISTFILE$      2030  2040

LOW.BYTE        540   560  4010  4030  6030  6060

N              3040  3070  3070  3070  3070

OUTPUT         2040

PASS            820   860   860   870

PASSES          840   870

PERPOS         2010  2020  2020  2030

POINTER         120  7010  7030  7040  7040  7050

SORTED          880   900   910   980  1020

TRUE            120   910

X$              320
```


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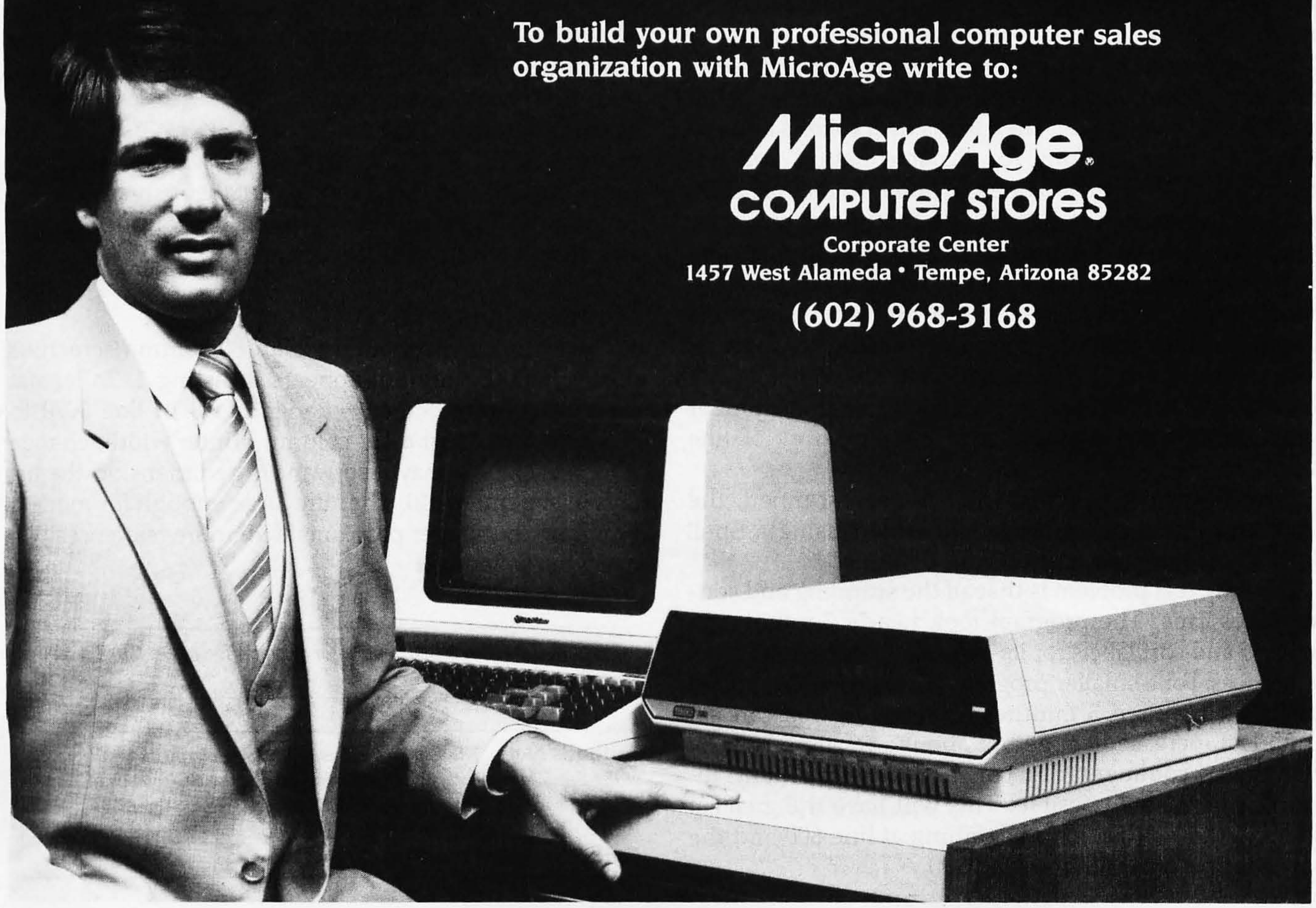

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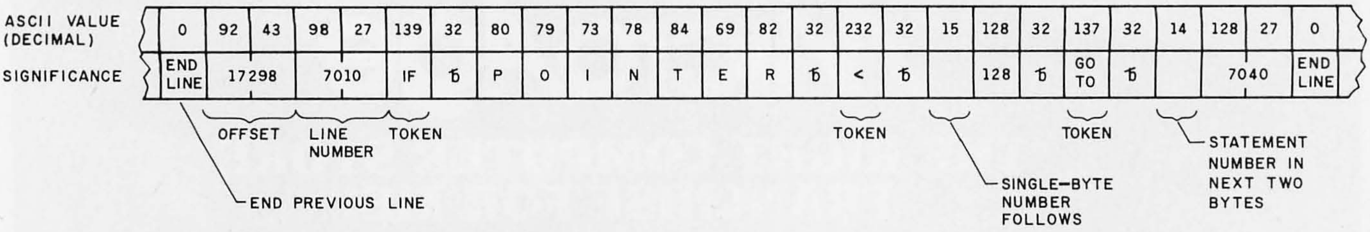

Figure 1: *Tokenized format for line number 7010: 7010 IF POINTER <128 GOTO 7040.*

Text continued from page 378:

The program skips over all coded numbers except those prefixed by an ASCII 14. This code signifies a 2-byte number that is a program line-number reference, following a GOTO or GOSUB, for instance. The cross-reference listing program treats line-number references as labels and lists all lines referenced by other lines. This can help you find all the places in a program that call a certain subroutine.

How It Works

The format of the lines in a tokenized program file is shown in figure 1. The first 2 bytes are the BASIC offset address to the next program line. Our only interest in it is when it is 0 because a 0 offset signifies the end of the program. The next 2 bytes contain the line number, with the least significant byte first. These are followed by a series of bytes, including tokens, coded numbers, and variable names, up to the end of the line, indicated by an ASCII value of 0.

The approach of the cross-reference utility, then, is very simple. It makes a note of the line number being scanned at the moment, then skips over tokens and encoded numbers, looking for variable names and references to other program lines. When it finds the beginning of a variable name, it builds the name, character by character, until it comes to an ASCII code that can't be part of a variable name. If the variable has been explicitly typed (marked by a $, #, !, %), that character is added to the end of the name. If the variable is subscripted, then "(SUB)" is added. Once complete, the variable name is stored in an array; the line number where it appears is stored in a parallel array of line numbers.

Once the entire program file has been scanned, the label and line-number arrays are sorted using a Shell sort. Then they are written to a disk file.

The only real problem is that all the scanning and sorting takes time. The program took nearly 7 minutes to process and sort labels for its own 145 lines and 245 label references. For a smaller program (123 references and 133 labels), it required 3 minutes 45 seconds. You can get a modest increase in speed of about 5 to 10 percent by eliminating comments and consolidating statements into one line where possible. This will have the greatest effect in the WHILE loop beginning at line 600 and the sort routine beginning at line 800.

Be Wary

In order not to slow the program down further, I kept it as simple as possible. Because of this, a few bogus variables may creep into your listing. These are words used as part of BASIC statements that are not tokenized. They include the following: ALL in a CHAIN statement, BASE in an OPTION BASE statement, B or BF in a LINE statement, R in a LOAD statement, AS in a FIELD or NAME statement, and AS, APPEND, or OUTPUT in an OPEN statement. None of these is a reserved word, and they are therefore not tokenized. Thus, if you use them in a program, the cross-reference utility will treat them as variable names. Note that both AS and OUTPUT appear in listing 2.

The cross-reference listing is written to a sequential disk file, which may be read later. The file name for the listing is the file name of the program file with an extension of CRF. If the original program file were MYPROG.BAS, the listing would appear on file MYPROG.CRF. To display the listing on your monitor, you first need access to the DOS (disk operating system)—execute SYSTEM from BASIC. When in DOS, execute TYPE MYPROG.CRF. If you want a hard copy, press the Ctrl and PrtSc keys simultaneously prior to executing the TYPE command; the listing on the monitor will then be output to the printer.

Modifications

The output is formatted for an 80-column screen or printer as the program appears in listing 1. To format for a 40-column screen, change N>8 in line 3070 to N>3. To format for a 132-column printer width, change it to N>16. You may also want to redimension the arrays in statement 110. They are large enough for modest programs, but larger programs with more references will need more space.■

James A. Folts is an assistant professor of journalism at Oregon State University, Corvallis, OR 97331.

Author's Note: *The slowness of this utility is primarily due to the slowness of the BASIC interpreter. The author has an object-code (compiled C) version of this algorithm that runs about 10 times faster than the BASIC version. Both copies are available on disk for $15. Contact James A. Folts, 755 SW 55th, Corvallis, OR 97333.*

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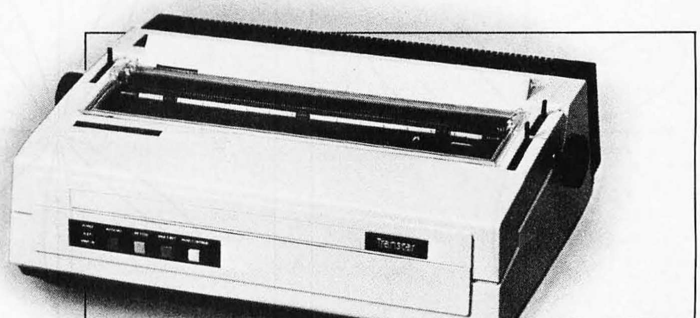

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Curious Coordinates for Computer Graphics

An elliptical coordinate scheme makes it easy to represent figures

by Roger C. Millikan

Plotters and dot-matrix printers that can handle graphics usually use x,y coordinate systems, or Cartesian coordinates. Yet universal and useful as those systems are, they are not always the best choice for all plotting tasks. Some figures can be much more easily specified in other coordinate systems.

The roses in figure 1—one with three and the other with seven petals—are a good example. The equations that describe them are much more simply written in polar coordinates than in x,y coordinates. Perhaps more important is that, when polar coordinates are used to represent the roses, the integer multiplying T in the equation corresponds to an obvious feature of the resulting curve: the number of petals.

The role that coordinate systems play in graphics is analogous to the role that languages play in programming. Although a computer has a machine instruction set, the instructions are inconvenient for general use; therefore, high-level languages are set up to ease the task of specifying solutions to problems. Similarly, a plotter's x,y coordinate system is seldom convenient to use unless it's scaled to match a particular problem. You must therefore define a new and more appropriate coordinate system to match the problem at hand. And just as a compiler maps a high-level source language into a computer's instruction set, you can use a subroutine to map a coordinate system into a plotter's coordinates.

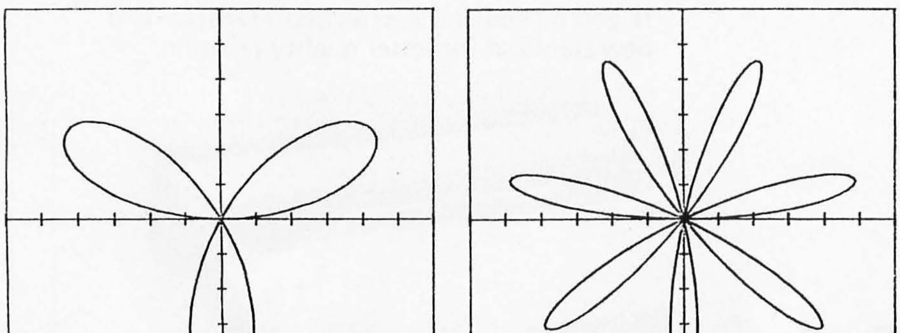

Figure 1: *Three- and seven-leaf roses. In Cartesian coordinates, the equation for the three-leaf rose is $x^4-3x^2y+2x^2y^2-y^3+y^4=0$. In polar coordinates, the equation becomes $r=sin(3T)$. Can you guess the seven-leaf rose equation?*

Conversion Becomes Easy

The idea of using a subroutine to convert to x,y coordinates is simple, yet it gives you a lot of freedom. Polar coordinates may have seemed difficult to work with when you were in school, but programs running on calculators or computers have eased the conversion between polar and x,y systems. Given this ease, why stop with polar coordinates? Perhaps you can generalize them in interesting ways. Or maybe you'll discover systems that will make it easy to produce interesting graphics. All you need is the appropriate conversion subroutine for any set of coordinates.

Not surprisingly, symmetries in any coordinate system are reflected in the kind of curves that are easy to draw or specify. An Etch-a-Sketch,

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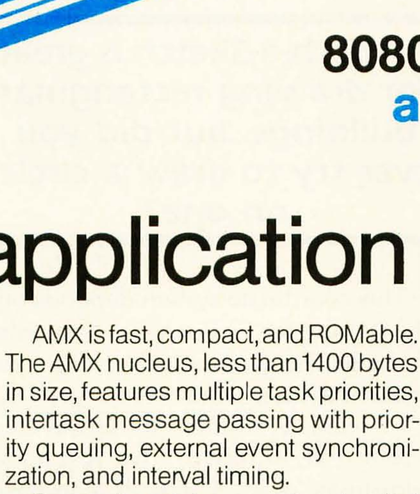

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for example, is great for drawing rectangular buildings, but did you ever try to draw a circle on one? Using polar coordinates, on the other hand, makes it especially easy to represent circular figures. You can, in fact, tailor the type of coordinates to suit any given purpose. If you want to draw elliptical figures, why not use an elliptical coordinate system?

Coordinate Systems with Parameters

Polar coordinates are based on the circle, the limiting form of an ellipse, where the distance between the two foci becomes zero. This fact suggests a natural generalization of polar coordinates: a system, which could be called elliptical polar coordinates of scale C, based on confocal ellipses in which each focus is a distance C from the origin. The variable C, a parameter of the coordinate system, is specified by the user. If possible, the system should be set up so that it becomes the standard polar-coordinate system when C=0. Then the conversion subroutine can provide conversions for a range of coordinate systems, including familiar ones.

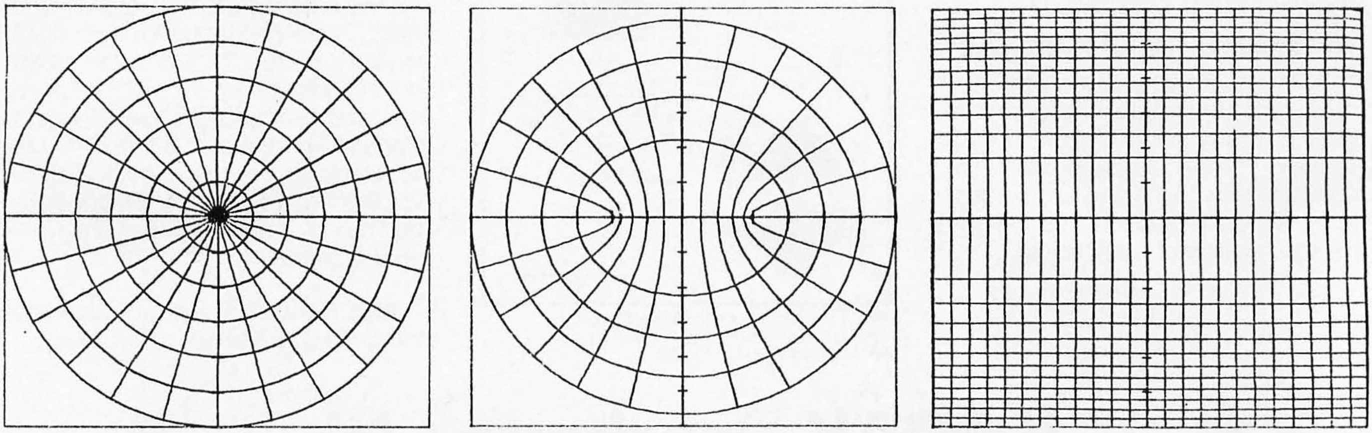
Such a system is shown in figure 2b. The coordinates of a given point are R and T. In polar coordinates (figure 2a), R represents the radial distance from the pole to the point. The corresponding quantity in the elliptical system (figure 2b) is half the sum of the distances from the point to the two foci. The elliptical system's angle T is analogous to the polar angle T. This is best seen in the plotting of constant coordinate lines as shown in figure 2. In figure 2b, where C=400 (i.e., each focus is 400 units from the origin along the x-axis), the ellipses are obtained for different constant values of R, while T goes from 0 to 2π radians. The lines that appear as hyperbolas result from setting the angle T to different constant values and, for each value of T, incrementing R from its lowest possible value (R=C) to higher ones. The conversion subroutine maps the grid of lines produced onto the normal rectangular grid of x,y lines that plotters use.

An Etch-a-Sketch is great for drawing rectangular buildings, but did you ever try to draw a circle on one?

This coordinate system depends on the parameter C. But what happens if you let that parameter become zero or, on the other hand, very large? The C=0 case is shown in figure 2a, where, as expected, the resulting coordinate grid is that of standard polar coordinates. Polar coordinates, then, are a special case of our more general coordinates. Perhaps more surprising is the case where C becomes large. Figure 2c depicts the grid that results when C=10,000. In a small region near the origin, the grid appears rectangular. It is linear in the x direction as T increases but nonlinear in the y direction as R increases. Thus the elliptical system can smoothly transform rectangular-type coordinates to polar types.

By choosing a particular value for the parameter C, a particular instance of elliptical coordinates is selected. Yet C can also be treated as a variable in a computer-graphics program, and you can use this modulation of the coordinate system to produce special effects. For example, consider the rose with five petals that has the polar equation R=1000cos(5T). In the elliptical polar system of scale 400, the rose becomes a stylized stick man. And by redrawing him for C=300, 200, and 100 (figure 3), we take him through his exercises.

The BASIC program in listing 1 provides the conversion subroutine from these elliptical polar coordinates of scale C to Cartesian coordinates. A simple conversion, it needs little explanation. In it, the variable R cannot be less than C. In the polar case, this requirement corresponds to that of the radial distance from any point to the origin being positive. Mathematically, this restriction prevents the square root in the conversion from becoming imaginary. Should you call the subroutine with R<C, the minimum possible value, R=C, is used to generate the x,y coordinates. Handling an error condition this way permits the plot to proceed without being hampered by error messages. And to avoid corrupting further computations, the original value of R is maintained upon exiting the subroutine.



(2a) **(2b)** **(2c)**

Figure 2: *Elliptical polar coordinate grids for different values of the scale parameter C. In (2a), C=0, in (2b), C=400, and in (2c), C=10,000.*

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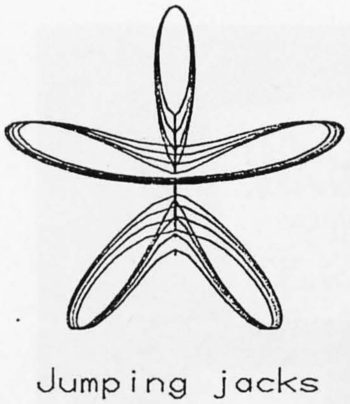

Figure 3: *The result of changing the coordinate system parameter.*

Listing 1: *This BASIC program serves as the subroutine for converting elliptical polar coordinates of scale C to Cartesian types.*

```
1000 REM  SUBROUTINE CONVERTS ELLIPTICAL POLAR COORD
1002 REM  OF SCALE 'C' TO CARTESIAN X,Y COORDINATES.
1004 REM  'C' IS DISTANCE FROM ORIGIN TO EACH FOCUS.
1006 REM  FOR C=0, COORD. BECOME STD POLAR COORD.
1008 REM  POINT IS P(R,T) WHERE 'R' IS RADIAL DISTANCE
1010 REM  'T' IS POLAR ANGLE IN RADIANS.  IF R<C, THE
1012 REM  CONVERSION USES R=C (IN THE POLAR CASE THIS
1014 REM  MEANS THE RADIUS MUST BE POSITIVE).
1016 REM
1018 Q = R
1020 IF R >= C GOTO 1024
1022 Q = C
1024 X = Q*COS(T)
1026 Y = SQR(Q*Q-C*C)*SIN(T)
1028 RETURN
```

Additional 2-D and 3-D Coordinates

The elliptical polar system discussed here is just one example of a coordinate system that serves a specific purpose. Many other two-dimensional curves could serve as a basis for coordinate systems. The intersecting sets of logarithmic spirals in the seed arrangement of sunflowers is one interesting possibility that would differ completely from polar or rectangular systems. Once you've developed a conversion subroutine, you can try old plotting programs using the new coordinate system—often with surprising results.

Three-dimensional space offers even more freedom for coordinate explorations. Helical systems and toroidal systems are possible. Of course, you'd need a way to depict the results on a two-dimensional plotter . . . But that's just another subroutine.■

Roger C. Millikan (5475 Toltec Dr., Santa Barbara, CA 93111) is a professor of chemistry at the University of California, Santa Barbara. His interest in computing dates back to a $1 million machine—the GE225 running Dartmouth BASIC—one about as powerful as the Z80 microcomputers of today.

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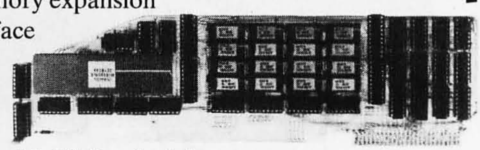

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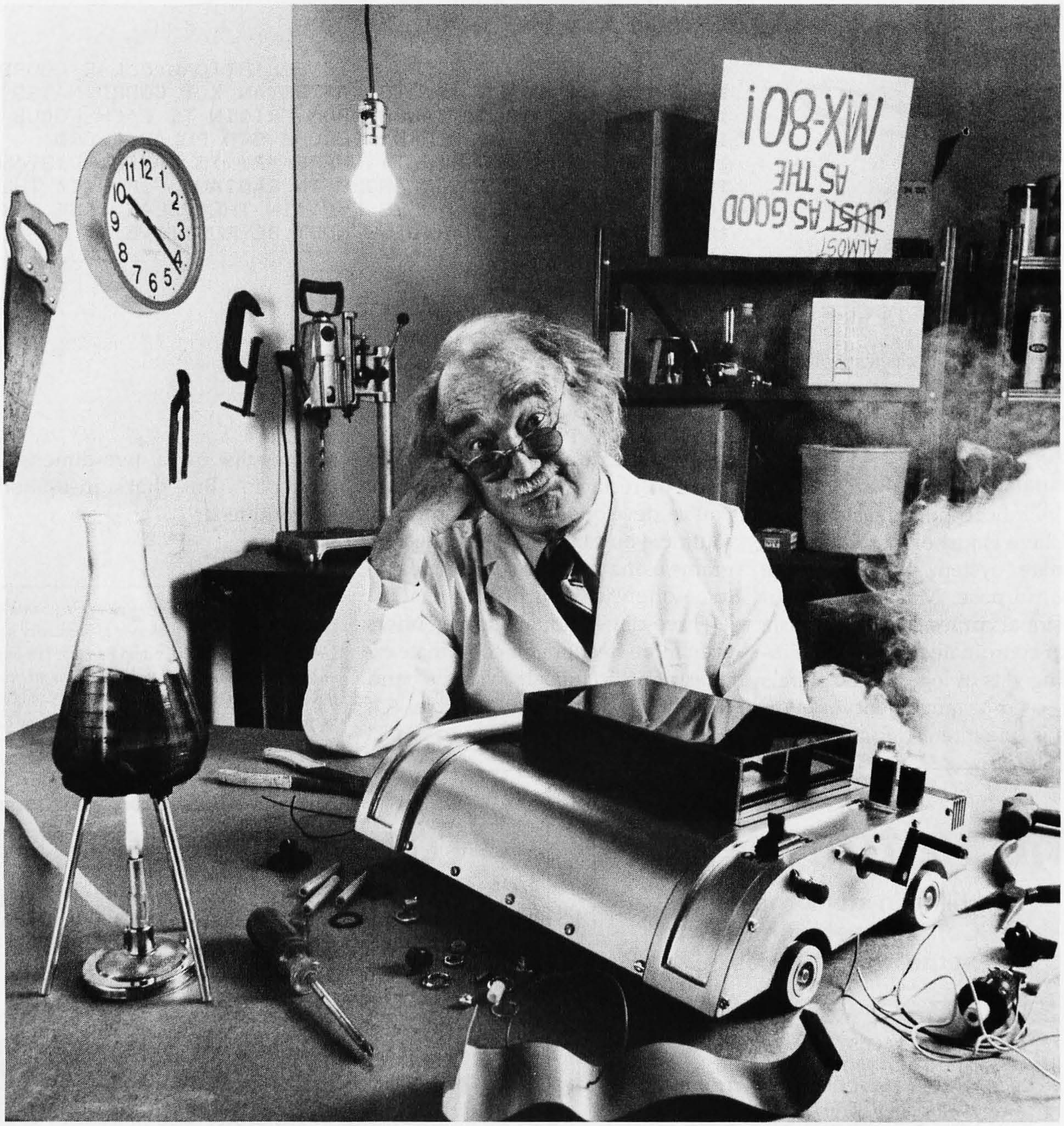

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A Gauss-Jordan Elimination Method Program

A flexible routine solves simultaneous linear equations

by Patrick E. McGuire

You can often represent a technical problem as a system of simultaneous linear equations, forming the familiar set of n equations and n unknowns. One common approach for solving these equations is the Gauss-Jordan elimination method, which is rigidly systematic and straightforward for computer applications. To demonstrate, I'll describe a versatile program, which does the following, using the Gauss-Jordan elimination method:

1. Given a matrix of coefficients from any arbitrary-size system of equations, the program solves for the unknowns.
2. When used in its entirety, the program functions in a calculator mode, i.e., coefficients are entered in response to program prompts. The unknowns are then solved. Also, the determinant of the matrix is generated as well as the inverse. The latter is a preliminary step for matrix division. The input is echoed to a line printer, and, of course, the results are printed.
3. When modified slightly, the program performs as a concise subroutine for use in a larger program. In this case, the input takes the form of an array supplied by the calling program. Output from the subroutine is then made available in an extended form of the same array.

The program given in listing 1 is written in Level II (Microsoft) BASIC as implemented on the TRS-80 Model I microcomputer. You should have few, if any, problems adapting the program to other machines.

I'll briefly review the steps involved in the Gauss-Jordan elimination method to clarify how you can use listing 1.

The Method

Any system of simultaneous equations can be represented in general form as shown in figure 1a. A square array formed by the coefficients of x_i from figure 1a establishes the coefficient matrix. You append the values from the right-hand side of the equations to the array to form the augmented matrix, as shown in figure 1b.

You can represent the Gauss-Jordan elimination method operating on this augmented matrix in pseudocode as shown in figure 2. When you read this procedure, note that the array is continually altered as the various loops progress. Any term labeled "a" in the process is the matrix element that remains after all previous operations have been completed. After these nested loops are performed, the solutions appear in the right-hand column of the augmented matrix as shown:

$$
\begin{aligned}
x_1 &= a'_{1,n+1} \\
x_2 &= a'_{2,n+1} \\
x_3 &= a'_{3,n+1} \\
&\text{——} \\
&\text{——} \\
&\text{——} \\
x_n &= a'_{n,n+1}
\end{aligned}
$$

The primes indicate the values derived from the numerous divisions, multiplications, and subtractions performed in the loops.

Text continued on page 398
Listing on page 396

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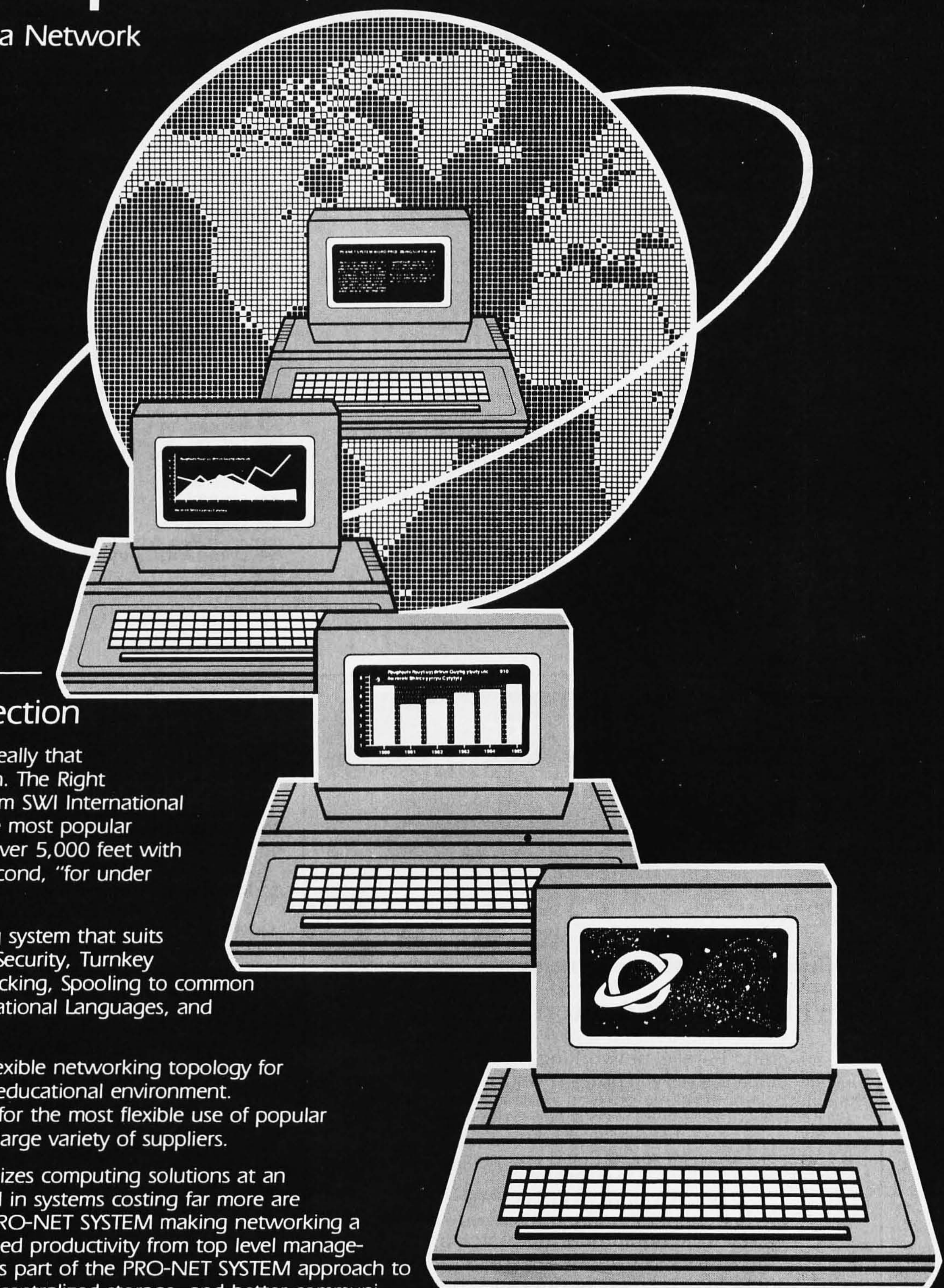

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Listing 1: *This version of the program stands alone and can be used in a calculator mode (as defined in the text) to solve linear systems.*

```
100 '      Program module for solution of arbitrary size
110 '      systems of linear equations. Solution method is
120 '      Gauss-Jordan Elimination. In addition to the
130 '      solution vector the matrix inverse is also derived.
140 '------------------------------------------------------------
150 '                 Patrick McGuire
160 '           Lafayette, LA ---  1980
170 '------------------------------------------------------------
180 '------------------------------------------------------------
190 ' The first section is a small utility for use in testing
200 ' the module using keyboard array entry. It may also be used
210 ' "as is" to solve linear systems.
220 CLS
230 INPUT"ENTER MATRIX SIZE, (N X N), ENTER N";N
240 DIM A(N,N*2+1)
250 FOR X=1 TO N
260 FOR Y=1 TO N+1
270 PRINT" ENTER ELEMENT ";X;Y
280 INPUT A(X,Y)
290 NEXT Y
300 NEXT X
310 ' End utility section
320 '----------------------------------------------------------
330 ' Extend matrix array for inverse generation
340 Y=N+1
350 FOR X= 1 TO N
360 Y=Y+1
370 A(X,Y)=1
380 NEXT X
390 ' End extension section
400 '------------------------------------------------------
410 ' This section prints input and extended array
420 LPRINT TAB(15);"GAUSS-JORDAN ELIMINATION"
430 LPRINT TAB(15);"Input Data and Array Setup"
440 FLAG=1: ' Suppress determinant printing
450 GOSUB 870
460 FLAG=0: ' Reactivate determinant printing
470 LPRINT: LPRINT
480 ' End input printing section
490 ' ---------------------------------------------------------
500 ' ---------------------------------------------------------
510 ' Begin actual solution
520 ' ---------------------------------------------------------
530 ' Pivot row normalization section: divides by the diagonal
540 DET=1: 'Initialize the determinant
550 FOR R=1 TO N
560 J=2*N+1
570 DIV=A(R,R)
580 DET=DET*DIV: ' Update determinant
590 FOR H=1 TO J
600 A(R,H)=A(R,H)/DIV
610 NEXT H
620 ' End row normalization section
630 ' ------------------------------------------------------------
640 ' Non-Pivot row reduction section
650 FOR S=1 TO N
660 Q=A(S,R)
670 IF S=R GOTO 710
680 FOR T=1 TO J
690 A(S,T)=A(S,T)-A(R,T)*Q
700 NEXT T
710 NEXT S
720 ' End row reduction section
730 ' ----------------------------------------------
740 NEXT R
750 ' ----------------------------------------------
760 ' End of solution sections
770 ' ----------------------------------------------
780 ' ----------------------------------------------
790 ' Print heading for solution output
800 LPRINT TAB(15);"Gauss-Jordan Elimination Results"
810 GOSUB 870
820 FOR P=1 TO 6: LPRINT: NEXT P
830 END
840 '
850 ' ----------------------------------------------
860 ' Line printer output subroutine
870 FOR X=1 TO N
880 FOR Y=1 TO 2*N+1
890 LPRINT USING "###.###";A(X,Y);
900 LPRINT "    ";
910 NEXT Y
920 LPRINT
930 NEXT X
940 LPRINT
950 IF FLAG=1 GOTO 970
960 LPRINT "DETERMINANT = ";DET
970 RETURN
```


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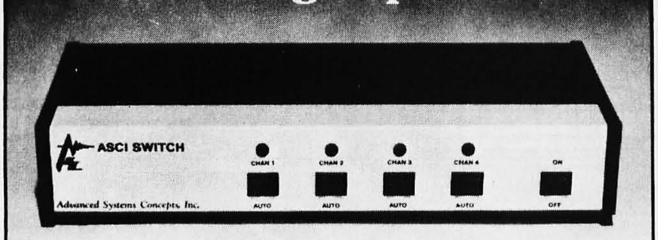

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(1a)

$$
\begin{array}{l}
a_{11}x_1 + a_{12}x_2 + a_{13}x_3 + \dots\dots\dots\dots a_{1n}x_n = a_{1,n+1} \\
a_{21}x_1 + a_{22}x_2 + \dots\dots\dots\dots\dots\dots a_{2n}x_n = a_{2,n+1} \\
a_{31}x_1 + \dots\dots\dots\dots\dots\dots\dots\dots a_{3n}x_n = a_{3,n+1} \\
\vdots \qquad\qquad\qquad\qquad\qquad\qquad \vdots \\
a_{n1}x_1 + \dots\dots\dots\dots\dots\dots\dots\dots a_{nn}x_n = a_{n,n+1}
\end{array}
$$

(1b)

$$
\begin{array}{llllll}
a_{11} & a_{12} & a_{13} \dots\dots\dots\dots & a_{1n} & a_{1,n+1} \\
a_{21} & a_{22} \dots\dots\dots\dots\dots & & a_{2n} & a_{2,n+1} \\
a_{31} \dots\dots\dots\dots\dots\dots & & & a_{3n} & a_{3,n+1} \\
\vdots & & & & \vdots \\
a_{n1} \dots\dots\dots\dots\dots\dots & & & a_{nn} & a_{n,n+1}
\end{array}
$$

Figure 1: *A general representation of any set of simultaneous equations is shown in figure 1a. The coefficient array from the system of equations in 1a sets up the solution for x_1, x_2, x_3, etc., when you form the augmented matrix shown in 1b by appending the values from the right-hand side of the equation to the array.*

```
for k = 1 to n
  for i = 1 to n
    for j = 1 to (n + 1)
      a_ij = a_ij/a_kk, when i = k
              or
      a_ij = a_ij - (a_kj/a_kk)(a_ik), when i ≠ k
    next j
  next i
next k
end
```

Figure 2: *The Gauss-Jordan elimination method, shown here in pseudocode, can be used to solve most simultaneous systems of equations.*

$$
\begin{array}{llllllll}
a_{11} & a_{12} & a_{13} \dots\dots\dots\dots & a_{1,n+1} & 1 & 0 & 0 \;\dots\dots & 0 \\
a_{21} & a_{22} \dots\dots\dots\dots\dots & & a_{2,n+1} & 0 & 1 & 0 \;\dots\dots & 0 \\
a_{31} & a_{32} \dots\dots\dots\dots\dots & & a_{3,n+1} & 0 & 0 & 1 \;\dots\dots & 0 \\
\vdots & & & & & & & \vdots \\
a_{n1} \dots\dots\dots\dots\dots\dots & & & a_{n,n+1} & 0 & 0 & \dots\dots & 1
\end{array}
$$

Figure 3: *Appending the array of 1s and 0s prior to performing the elimination procedure automatically yields the matrix inverse.*

Text continued from page 394:

The inverse of the coefficient matrix can also be generated simultaneously during this routine. To do this, the original array (see figure 1b) is extended to include an identity matrix of size n, as shown in figure 3. Then, the inner loop of the pseudocode is extended to

$$\text{for } j = 1 \text{ to } (2n + 1)$$

After the program is run, the matrix inverse is the result of the operations performed on the identity matrix.

The coefficient-matrix determinant can also be concurrently derived by taking the product of each term a_{kk}, as it is encountered, while the loops proceed. Called *pivot elements*, these terms lie along the diagonal of the matrix.

For additional information on linear systems analysis and matrix manipulation in general, see *Computational Matrix Algebra* by David Steinberg (McGraw-Hill, 1974).

Using the Program

Use of the program in listing 1 is straightforward. As a problem-solving tool or teaching aid, the entire listing as given should be employed.

Operating as a stand-alone program, the routine first asks for the matrix size n of the $n \times n$ coefficient array. Then, the user is prompted to enter the augmented array, element by element. The first entry is element 1,1 and the last is n, $n+1$.

After the last data entry, the program adds the array extension for generating the inverse, prints the input data (with extension), and proceeds with the solution. The solution sequence performed next is similar to the preceding pseudocode. Finally, the program prints the solution array along with the determinant.

Figure 4 shows a sample run based on the following set of equations:

$$
\begin{aligned}
2x_1 - 4x_2 + 5x_3 &= 6 \\
7x_1 + 4x_2 + 5x_3 &= 6 \\
2x_1 - 3x_2 + 6x_3 &= 5
\end{aligned}
$$

Note that the solutions

$$x_1 = 1.443, \; x_2 = -0.902, \text{ and } x_3 = -0.098$$

appear in the $n+1$ column of the resulting array. In this case, the solution vector lies in the fourth column, and the determinant of the coefficient matrix given in the original first three (n) columns is 61.

You should use the version in listing 2 when you want the program to be a subroutine in a larger program. The calling program must have previously filled the array A with data and specified the value of N, where N equals n of an $n \times n$ system. After the equation is solved, the main program can extract the solution vector and/or the inverse from the extended array. The determinant is also available as the variable DET. The calling program must include a dimension statement allotting enough space for the largest array (n by $2n + 1$) to be solved.

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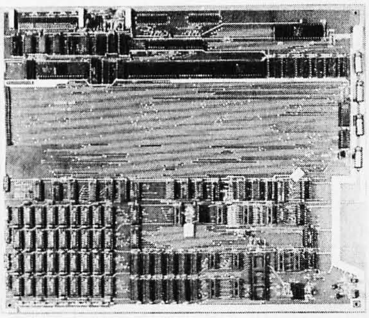

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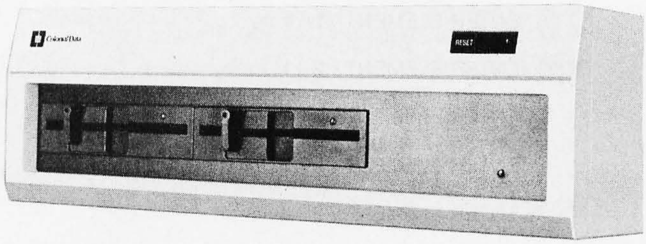

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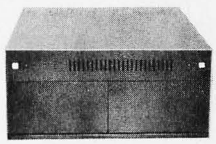

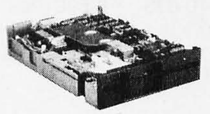

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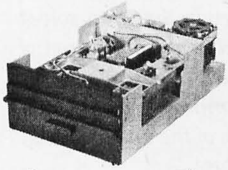

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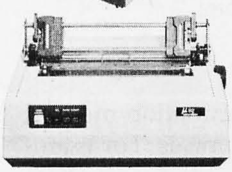

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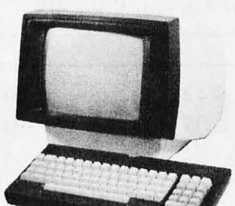

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(4a)

```
ENTER MATRIX SIZE, (N×N), ENTER N? 3
 ENTER ELEMENT  1  1
? 2
 ENTER ELEMENT  1  2
? -4
 ENTER ELEMENT  1  3
? 5
 ENTER ELEMENT  1  4
? 6
 ENTER ELEMENT  2  1
? 7
 ENTER ELEMENT  2  2
? 4
 ENTER ELEMENT  2  3
? 5
 ENTER ELEMENT  2  4
? 6
 ENTER ELEMENT  3  1
? 2
 ENTER ELEMENT  3  2
? -3
 ENTER ELEMENT  3  3
? 6
 ENTER ELEMENT  3  4
? 5
```

(4b)

Gauss-Jordan Elimination
Input Data and Array Setup

2.000	−4.000	5.000	6.000	1.000	0.000	0.000
7.000	4.000	5.000	6.000	0.000	1.000	0.000
2.000	−3.000	6.000	5.000	0.000	0.000	1.000

(4c)

Gauss-Jordan Elimination Results

1.000	0.000	0.000	1.443	0.639	0.148	−0.656
0.000	1.000	0.000	−0.902	−0.525	0.033	0.410
0.000	0.000	1.000	−0.098	−0.475	−0.033	0.590

Determinant = 61

Figure 4: *The example system of equations given in the text is solved here using the program in listing 1. Figure 4a is an illustration of the data-entry process as it appears on screen. Figure 4b is the augmented matrix with appended 1s and 0s formed from the input data. Figure 4c shows the solved matrix; values of the unknowns* x_1, x_2, *and* x_3 *are in the fourth column in this case.*

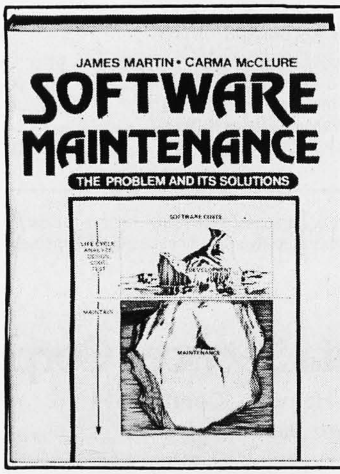
Summary

The version of the Gauss-Jordan elimination method described here includes some compromises. For example, if any of the diagonal elements (a_{11}, a_{22}, a_{33}, etc.) are or become equal to 0, the solution fails. Ways exist to overcome this deficiency, but the inverse generation and determinant features are destroyed if you use simpler methods. There is another method, called the Maximum Pivot method, which overcomes the zero-diagonal problem and retains the other features. However, this procedure is significantly more complicated and time-consuming. Fortunately, most physical problems do not exhibit the zero-diagonal difficulty.■

Listing 2: *This is an abbreviated form of listing 1, which is intended for use as a subroutine in a larger program.*

```
50000 '      Subroutine to perform Gauss-Jordan solution
50010 '      of simultaneous linear equations. The matrix
50020 '      inverse and determinant are also derived.
50030 '------------------------------------------------------------
50040 '                Patrick McGuire
50050 '           Lafayette, LA ---  1980
50060 '------------------------------------------------------------
50070 '------------------------------------------------------------
50080 ' Extend matrix array for inverse generation
50090 Y=N+1
50100 FOR X=1 TO N
50110 Y=Y+1
50120 I=N+2: J=2*N+1
50130 FOR K=I TO J
50140 A(X,K)=0
50150 IF K=Y THEN A(X,K)=1
50160 NEXT K
50170 NEXT X
50180 ' End extension section
50190 ' ---------------------------------------------------------
50200 ' ---------------------------------------------------------
50210 ' Begin actual solution
50220 ' --------------------------------------------------------
50230 ' Pivot row normalization section: divides by the diagonal
50240 DET=1: 'Initialize the determinant
50250 FOR R=1 TO N
50260 J=2*N+1
50270 DIV=A(R,R)
50280 DET=DET*DIV: ' Update determinant
50290 FOR H=1 TO J
50300 A(R,H)=A(R,H)/DIV
50310 NEXT H
50320 ' End row normalization section
50330 ' -------------------------------------------------------
50340 ' Non-Pivot row reduction section
50350 FOR S=1 TO N
50360 Q=A(S,R)
50370 IF S=R GOTO 50410
50380 FOR T=1 TO J
50390 A(S,T)=A(S,T)-A(R,T)*Q
50400 NEXT T
50410 NEXT S
50420 ' End row reduction section
50430 ' ---------------------------------------------
50440 NEXT R
50450 ' ---------------------------------------------
50460 ' End of solution sections
50470 ' ---------------------------------------------
50480 ' ---------------------------------------------
50490 RETURN
```

Patrick E. McGuire (102 Duncan Circle, Lafayette, LA 70503) is a registered professional petroleum engineer and assistant district manager of a major oil company.



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The Future of Software Design

Industry looks to software as the source of the next wave of innovation in microcomputers

by William Gates

Software, after years of taking a backseat to hardware, has finally come into its own. Today there is general acknowledgment of software's importance. It is the bridge between the machine and the user—the tool that brings the power of the computer to the user. And software is defining today's crucial information issues.

Instead of the emphasis of past years on building better and more powerful machines, the emphasis now is on how to harness the full power of the existing hardware through improved software design. The promise is that the existing machines could do the job much better—more easily, more efficiently—if software were better designed.

And this promise, in turn, leads straight into several key issues that are facing software developers today. What, exactly, constitutes a better design? Of the various approaches that software design can take, which will be most effective in helping users access the full potential of their machines?

Currently software developers face five major issues. None has easy answers. The stand that each of the major players in the field chooses to take on these issues—and the degree to which the ultimate judge, the user marketplace, accepts each stand—will determine the direction of software design.

A great deal of money will be invested in these choices. The cost of developing a fully integrated family of applications is enormous. Apple talks of investing \$50 million to develop a complete applications family; Xerox views the job in terms of hundreds of man-years. Therefore, each software developer is going to have to take a good hard look at each of these issues and make its choice with great care. A wrong choice will be costly at best; at worst, it could spell financial disaster.

In this article, I'll examine today's central software issues, analyze the pros and cons of the possible choices within each issue, and hazard some guesses as to which directions will prove to hold the key to the software packages of the future.

This month the BYTE West Coast editors relinquish their forum to Bill Gates. As chairman of the board of Microsoft Corporation, Gates directs the efforts of one of the microcomputer industry's major software houses and has some definite opinions about the arrival of the soft revolution.

Integration

Integration has been a byword in the software industry for some time. But the issue here is not superficial integration. I am not talking about taking various products and calling them by similar names. I am not even talking about moving the data back and forth between the products through some sort of low-level numeric description, where special commands must be given each time the user wants to move data from one application to another.

Such an approach, although *better* than no integration at all, presents the user with two major problems. First, special commands take considerable time and effort, both in the initial learning and in their application each time the data is to be moved. Worse yet, with this type of integration, important information about the data is lost. Take sales data, for example. In a particular application, users may have described sales by time period (daily, weekly, or monthly), by sales unit (sales rep, product line, or division), and by the form in which they want to print it. With today's level of integration, if they try to move this data from one application to another, they generally will lose some of these important descriptors. The data will be devoid of its full structure.

The two key features of real integration, then, are that it must capture all data descriptors and it must be automatic. That is, to get two applications to work together, there should be no need to continually move the data back and forth manually. If, for example, users need to combine data from their balance sheets and their income statements to do monthly reports, they should be able to specify what data they want the reports to include and in what format

it should be printed. The rest should be automatic—graphs, charts, and all—without any need to go back in and reinput or redescribe the data.

This is how fully integrated software will work. But the big question is, how do you get there? Basically, two possible approaches exist: either build one single application that does everything or else find better ways of moving data between separate applications.

The first approach has a definite appeal, in view of the fact that no one has yet developed a way of moving data between applications in a high-level form. But there are three significant drawbacks to the idea of building a single applications package that does it all.

First, there is the problem of specialized expertise. Even if one software developer had the expertise to build a complete set of generic applications—time scheduling, project scheduling, database development, electronic spreadsheets, and the like—it would be impossible to find a single vendor who had the expertise to build all the necessary vertical applications. And vertical packages specific to different professions or companies are going to be a major segment of the software market. This need, then, points to the importance of developing an approach to integration that lets different parties with specialized types of expertise come in and provide specific vertical applications of the various packages.

A second problem with the approach of developing a single application that does it all is that it requires the selection of a single data structure. Because a data structure that is ideal for one application may be clumsy and inefficient for another, the net effect of this approach is that it compromises individual applications. For example, an in-memory data structure that is well suited to a spreadsheet application may be poorly suited for a database package. In fact, it may be totally unusable. If users want to develop graphs from the data stored in all the separate cells of a spreadsheet, for example, and they have to move the cells around and give a special set of commands each time they need graphs drawn (or, alternatively, find a macro string that will accomplish the same end), they are not going to be likely to use the application very frequently. Clearly, different applications require different data structures to make them easy to use.

The third difficulty with the single-application approach is that the command structure could easily become overstrained. The number of different commands and decision trees could become a significant problem.

For all of the above reasons, Apple and Microsoft are in agreement that the best solution is to have multiple products that can easily pass data back and forth. This doesn't mean that the products cannot be priced as a single package, or that they can't all be on the screen at one time. But it does mean that they will be based on different data structures and will use different command structures.

User Interface

A second crucial decision area facing software developers today involves the development of standards for user interfaces. Developers are in general agreement on some of these issues. For example, it is generally accepted that packages should include online "help" files so that users can immediately call up a piece of help text that is designed for the specific context in which they find themselves. Similarly, menus written in standard English and full-sentence prompts are generally accepted. Visicorp, for example, is moving away from the use of coded commands (/) and toward the use of English words.

The big issue today in the area of user interfaces is the introduction of graphics. To many people, graphics implies the drawing of bar charts, isometric charts, etc. But the graphics issue is, in reality, far broader than that.

The question is how to present data on the screen. So far, companies have been fairly confined in how they use the screen to present data. For a long time, they could only put characters (and monospaced ones, at that) in specific positions on the screen. This may not seem like a problem at first glance. But stop and think for a minute: if every time you went to use a piece of paper or a chalkboard you had to take little letters and place them where you wanted them, wouldn't you find this approach to be restricting? You might find yourself using the paper or chalkboard a great deal less than you now do, when you have the freedom to put arbitrary images there in any form.

The new graphic technology, with its use of pixels and bit-mapping, is bringing this same richness to the computer screen. The ability to view the screen as a piece of paper and to put arbitrary images on it means that graphics are going to be used for a great deal more than just drawing graphs. Icons, for example, tell the user what is happening in a much more compact and compelling way than words. Cursor displays to show users their positions are another form of visual feedback. For example, when users are deleting something, the screen could show scissors moving around the material being deleted. Even graphs and diagrams will be revolutionized by the new graphics technology because the time and effort required to produce them will be significantly reduced. In fact, what the new graphics technology represents is a revolution in user interfaces.

The bottom line is that graphics are going to be a standard part of all computers. No machine that costs more than $1000 will be without a built-in bit-map graphics screen. And the software analog of that hardware statement is that, one year from today, no decent application software family, no decent language family, and no decent operating system will be without extremely high level support for this type of graphics capability. It will be no small task for the software developers to achieve this graphics integration, but it is a necessary task. Furthermore, the graphics capability is not going to be in the form of add-on packages that users go out and buy after they have bought their computers: it will be part of the definition of the machines themselves. As such, it will require

very high level primitives to allow the user to easily access the graphics capabilities.

As the above observations indicate, software developers are going to have to agree on some user-interface standards to allow the full power of this graphics revolution to be felt. First, they will need to develop some standards for incorporating the graphics capability into the machine. Apple is already moving in this direction with its development of a strong operating system as a foundation for such built-in features. Second, they will need to agree on some high-level operating system commands to make the graphics capabilities readily accessible to the user.

Data-Storage Metaphors

Selection of the most appropriate data-storage metaphor is one of the toughest issues facing the software industry today. Basically, this term refers to the way the user perceives the storage of data within the system. Take Apple's Lisa system, for example, which is supposed to be capable of being learned in 20 minutes. Learning the spreadsheet application is going to be easy only for people who are used to working with formulas—people who like formulas, who understand them, and who understand how they can work together in an interdependent fashion. A data-storage metaphor that is based on placing formulas in cells of a spreadsheet is never going to be easy for most people to learn, regardless of how the system is dressed up with easy-to-remember icons, simple English commands, and so forth.

Xerox, on the other hand, uses a linear, document-oriented metaphor. It includes different types of frames (text, graphics, and so forth), but the orientation is still that of a document, which is scrolled through in linear fashion.

The direction that Microsoft is taking is toward a database metaphor. We undertook a study within our own offices to look at the ways people ask about and record data. Our findings showed that the data itself is the key; people generally take a database approach in recording and accessing information. Someone wanting sales figures for the previous year, for example, would not create a spreadsheet with empty cells and then send it to the accounting department to have the cells filled in. Rather, the person would start with the data that he had and request the additional data needed to complete the picture.

You can see that the metaphor question is entirely separate from concepts such as graphic icons or windows. It is also a much more difficult issue to deal with. The effort, however, will definitely be worth our while: it is in this area, more than any other, that we can make the breakthroughs that will allow the ordinary user to view the computer as simple. A software approach built around the right metaphor will allow users to walk up to the machine, immediately see the data that they have put into the system, and then easily choose the applications that will allow them to view that data in the formats they need—all without having to refer to files, spreadsheet cells, formulas, or any other complex constructs.

Tying Personal Computers to Mainframes

A fourth major concern that software developers need to address is the growing interest in tying personal computers into mainframes. Because of the significant differences among mainframes, this is no simple matter. Mainframes—even those made by the same vendor—have different file handlers, different communications software, and different operating systems. The IBM 370 alone has at least six major operating environments and, within each of those, multiple databases. Creating the software that will allow a personal computer to tie into such a machine will not be a trivial task.

The problem is not simply tying two machines together. That has already been done: software exists that will turn the personal computer into a terminal, ignoring its local intelligence.

The difficulty is to create a method of tying the two together that will allow automatic database querying. Users should not, for example, have to know JCL (job-control language) to access data from the mainframe. Nor should they need to learn a complex set of command structures. Rather they should be able to query the computer for data anywhere in the system and have the system itself use its intelligence to retrieve that data. In fact, the way the data was initially described in the dictionary should tell the system where to go to get it—whether to go, for example, to the mainframe, Compuserve, or Dow Jones. Resolving this software problem will not be easy, but it must be accomplished; the increasing use of personal computers in large organizations makes this a central concern today.

Expanded Definition of an Operating System

An important development that you will be seeing in the near future is a greatly expanded definition of an operating system. Microsoft, for example, as the vendor of one of today's most popular operating systems, MS-DOS, is planning to incorporate an increasingly higher number of functions into that system. Graphics capabilities, user-interface capabilities, networking—all will be incorporated into the operating system. Instead of these functions being considered add-on products, they will automatically be a part of every machine. This means that applications writers will be able to assume that these functions are there and design their packages accordingly.

The Soft World Is Here

As the above observations indicate, the innovation taking place in the world of computers today originates with software. No longer do you need to go out and build better, more powerful hardware to achieve productivity improvements: you simply develop a new software package, and people can put it to use immediately in their existing machines. The revolution is here—and it is soft.■

William Gates is chairman of the board of the Microsoft Corporation (10700 Northup Way, Bellevue, WA 98004).

The 8086—An Architecture for the Future

Part 3: Instruction Set Continued

Program transfers, string manipulations, and processor-control instructions are covered

by Stephen A. Heywood

In the previous two articles, I introduced the 8086 instruction set and demonstrated how it began to fulfill programmers' needs. Memory variables can be designated as the destination of most operations, and the addressing modes support the needs of compilers. In this final part, I look at 8086 program transfers, string manipulations, and processor-control instructions.

Program Transfers

Instructions are fetched from memory using the CS register as the segment register and the IP register as the offset. The program-transfer instructions (see table 1) can change the contents of the CS and IP registers or just the IP register.

For example, the JMP (jump) instruction does an unconditional transfer to the target location. The two major forms of JMP are direct and indirect.

The direct JMP instructions have three forms: short, near, or far. The short and near JMP instructions add a displacement contained in the instruction to the IP register. Using a displacement instead of a direct address for these jumps helps the code become position-independent. This code can be located anywhere in memory because these jumps are a displacement from the current instruction instead of an absolute address. The short form contains a 1-byte displacement that adds to the IP register in order to jump +127 or −128 bytes from the next instruction. The near form contains a 2-byte displacement that adds to the IP register for jumps within a 32K-byte range. It can also be used to jump anywhere within the current program segment.

As noted earlier, a segment can be as long as 64K bytes. This is due to the offset being given by a 16-bit register. This addressing method makes the segments appear circular, as opposed to linear for earlier microprocessors. For example, if a

Mnemonic	Description of Operation
JMP target	Jump to target location
Jcond target	See table 2
LOOP target	Loop
LOOPE/LOOPZ target	Loop while equal/loop while zero
LOOPNE/LOOPNZ target	Loop while not equal/loop while not zero
JCXZ target	Jump if CX = 0
CALL target	Call procedure
RET optional-value	Return from procedure
INT type	Interrupt
INTO	Interrupt if overflow
IRET	Interrupt return

Table 1: *The 8086 program-transfer instructions are used to modify the values in the CS and IP registers or the IP register alone.*

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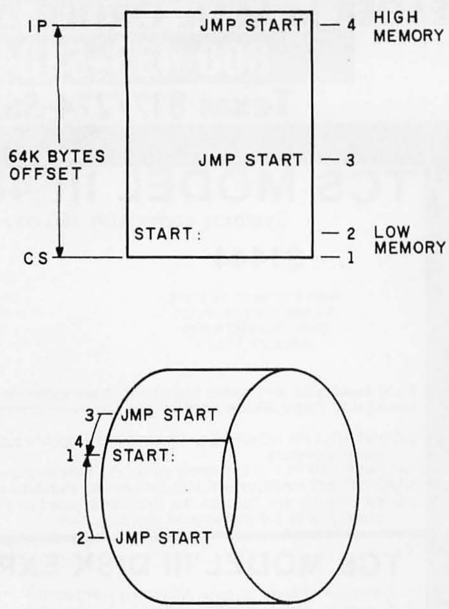

Figure 1: *A near JMP, which is greater than 32K bytes from the target location, uses a forward JMP with a positive displacement; if less than 32K bytes from the target, it uses a backward JMP with a negative displacement.*

displacement of +5 is added to the contents of IP, which contains a hexadecimal FFFE, then the IP register would contain a hexadecimal 0003 after the operation. Figure 1 graphically demonstrates this circular concept. Notice that a jump from the end to the beginning of the code area actually jumps forward instead of backward. Because the JMP instruction is more than 32K bytes from the beginning, the shortest distance is forward.

The far JMP replaces both the CS and IP registers with the 5 bytes contained in the instructions. This allows a jump to the beginning of a new segment. Modular programming takes advantage of this capability. Recall that modular programming splits up the programming task among several programmers and puts the final project together using a linker. To transfer control from one module to another, you would employ a far JMP.

Another use for the far JMP is after a reset. Delivering a reset to the 8086 causes the following: IP, DS, SS, ES, and the flags are cleared; the CS register reads hexadecimal FFFF; and the remaining registers are left alone. With CS equal to FFFF and IP equal to 0, the first instruction will be fetched from FFFF0. You would put a far JMP to the beginning of the program at this location.

Indirect-near JMP instructions transfer the contents of a general register or the contents of a memory location, using the addressing modes, to the IP register. This lets you use jump tables according to the values calculated. Figure 2 illustrates the use of an indirect jump on a value that has been input from a port to jump to a proper routine.

The far-indirect JMP uses the contents of a double-word memory location, using the addressing modes, to load the CS and IP registers. The first word transfers to the IP and the second word to the CS.

Conditional-jump instructions jump on the status of the 8086 flags at the time the instruction is executed. The tested flag conditions are shown in table 2. If the condition is TRUE, then the jump takes place; if the condition is FALSE, then the next instruction is executed. All conditional jumps are short jumps. Therefore, the target must be within −128 or +127 bytes of the next instruction. If you want to jump to a farther target, you would use the opposite condition to jump around a near JMP to the target location.

Conditional transfers can be divided into three categories: signed, unsigned, or either. Signed-conditional jumps look at the Overflow and Sign flags; the unsigned versions look at the Carry flag. Most of these instruc-

```
TABLE       DW    ERROR        ;This sets up a table of offsets to
            DW    ROUTINE1     ;the printer routine
            DW    ROUTINE2     ;DW means to define as a word
            DW    ROUTINE3
            DW    ROUTINE4
            DW    ROUTINE5

;This will input from a keyboard at port 0 a value from 1-5
;in ASCII and jump to the routine for that key. If the key
;is anything else it will go to an error routine.

START:      IN    AL,0         ;Get value from keyboard at port 0
            SUB   AL,30        ;Subtract hexadecimal 30 to change from ASCII
                               ;to a value
            CMP   AL,5         ;See if value is anything but 0-5
            JBE   INRANGE      ;If 0-5 then pointing correctly
            XOR   AL,AL        ;If not 1-5 then make it zero to go
                               ;to error routine
INRANGE:    XOR   AH,AH        ;Clear high byte to make word
            MOV   SI,AX        ;Place in index register to address
            SAL   SI,1         ;Double value for word indexing
            JMP   TABLE[SI]    ;Jump to the routine whose offset
                               ;is TABLE plus SI

ERROR:      __________         ;Routines would go here
ROUTINE1:   __________
ROUTINE2:   __________
ROUTINE3:   __________
ROUTINE4:   __________
ROUTINE5:   __________
```

Figure 2: *Using a JMP table.*

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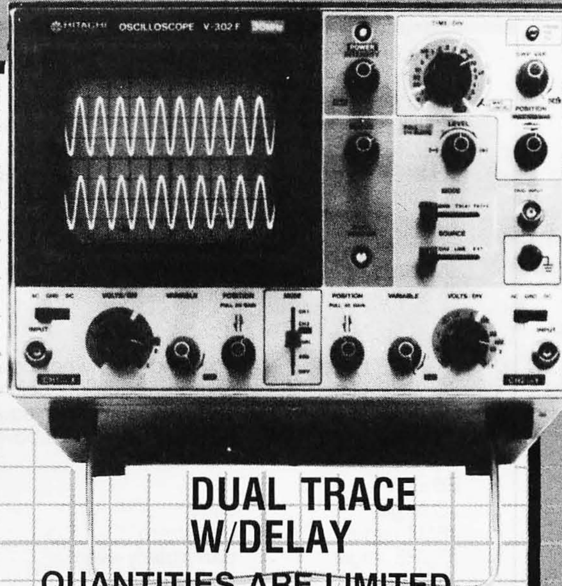

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Trigger Slope	±
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Mnemonic	Jump if	Condition Tested
Signed		
JG/JNLE target	greater/not less nor equal	((SF XOR OF) OR ZF) = 0
JGE/JNL target	greater or equal/not less	(SF XOR OF) = 0
JL/JNGE target	less/not greater nor equal	(SF XOR OF) = 1
JLE/JNG target	less or equal/not greater	((SF XOR OF) OR ZF) = 1
JO target	overflow	OF = 1
JS target	sign	SF = 1
JNO target	not overflow	OF = 0
JNS target	not sign	SF = 0
Unsigned		
JA/JNBE target	above/not below nor equal	(CF OR ZF) = 0
JAE/JNB target	above or equal/not below	CF = 0
JB/JNAE target	below/not above nor equal	CF = 1
JBE/JNA target	below or equal/not above	(CF OR ZF) = 1
Either		
JC target	carry	CF = 1
JE/JZ target	equal/zero	ZF = 1
JP/JPE target	parity/parity even	PF = 1
JNC target	not carry	CF = 0
JNE/JNZ target	not equal/not zero	ZF = 0
JNP/JPO target	not parity/parity odd	PF = 0

Table 2: *The conditional transfers jump on the status of certain flags and can only be short jumps.*

tions have more than one mnemonic. Again, this is to aid documentation purposes.

The conditions of greater and less refer to signed values; the conditions of above and below refer to unsigned values. These conditions should be used after you have done a CMP or a SUB instruction to ensure that you have the right flag conditions. You can see the difference between these two conditions by an example. If you compare the following hexadecimal bytes, FF to 00, and treat them as signed numbers, you are comparing a −1 to a 0 and determining that FF is less than 0. But if you compare these same numbers and treat them as unsigned numbers, you would find that 255 is above 0. This means that the conditional jump that you would use depends on how you treat the numbers.

Most programs use some type of software loop to perform such tasks as adding a value to a group of locations or a delay. Included in the 8086 instruction set are three instructions to make looping easier. These LOOP instructions use the CX register as a counter. They decrement the CX register and transfer to the target location if CX is not equal to zero. Otherwise, control transfers to the next instruction. Basically, this instruction replaces the following two instructions:

```
DCR   CX
JNZ   target
```

Except for one difference, no flags are affected by the LOOP instructions. Like the conditional transfers, LOOP instructions are only short transfers. Assembly-language programmers please note the following. If you like to use LOOP as a label in your programs, you might get an error from the assembler if you try it with the 8086.

The two conditional LOOP instructions are LOOPE (loop while equal)/LOOPZ (loop while zero) and LOOPNE (loop while not equal)/ LOOPNZ (loop while not zero). These two instructions have an alternate way of falling out of the loop. They decrement the CX register and transfer control to the target if CX is not equal to zero and the Zero flag is set for LOOPE or is cleared for LOOPNE.

The program will fall out of the loop if the CX register is zero, or prematurely fall out if the Zero flag is cleared for LOOP while equal/zero or if the Zero flag is set for the LOOP while not equal/not zero. Because the LOOP part of the instruction does

The 80186—

The 8086 is a popular microprocessor being used by hardware designers in many different systems. In fact, in varied applications system designers employ the same components. For example, an interrupt controller supplies the external interrupt type number for multiple interrupts. A clock generator furnishes the 8086 and system clocks as well as buffering the reset and ready input signals. Chip-select logic chooses different memory blocks and input/output devices. Often, these devices run at different speeds. Therefore, wait-state generators insert wait states in the microprocessor for accessing the slower devices. Timers and counters handle the timing and counting of events and tasks. To transfer data quickly between input/output devices and/or memory devices, DMA (direct memory access) controllers find widespread use. Chips supply control signals and give added drive to the data bus. However, all these components take up board space, and their interconnections make for a complex design and possible future problems. Consequently, Intel designed and manufactured an improved version of the 8086 microprocessor, called the 80186.

The 80186 contains the following hardware on one 68-pin chip:

- *8-MHz enhanced 8086 microprocessor*
- *programmable multilevel interrupt controller for as many as five external and three internal sources*
- *clock generator for internal and external clocks*
- *programmable memory and input/output chip selects for as many as six independent memory blocks and as many as seven peripherals*
- *three 16-bit programmable timer/counters, two external and one internal*
- *two independent programmable DMA channels for transfers up to 2 megabytes/sec per channel*
- *data-bus transceiver for added drive*
- *local bus controller for control signals*

These 80186 devices can be addressed in the input/output space or in the memory space for programming purposes. The control registers for the interrupt controller, the timers, the DMA channels, and the chip-select logic are grouped together in a 256-byte block. The 80186 has one additional register, the relocation register. It

A Lot of Hardware in One Package

locates this block in the input/output or memory space, contains the most significant 16 bits of the address where this block is located, determines the condition of the interrupt controller, and determines whether to interrupt if an ESC instruction comes in.

The 80186's microprocessor has been enhanced for added performance over the 8086. For example, the 8086 calculates addresses (segment + base + index + displacement) in an internal microcode routine. The 80186 uses a dedicated hardware adder to speed up address calculations. Also included in the 80186 is the hardware for 16-bit integer multiply and divide to speed up these instructions more than three times faster than the 8-MHz 8086. Furthermore, string manipulations have been streamlined by doing the string overhead of decrementing CX and checking flags in parallel so they execute as fast as the memory can handle them (up to 2 megabytes/sec). Multibit shifts and rotations execute each shift or rotation at a 1-bit/clock cycle.

The 80186 has the same instruction set as the 8086; therefore, code written for the 8086 can run on the 80186. Ten additional instructions are also included in the 80186, as listed in table 1.

For example, you can push an immediate 16-bit value or a sign-extended 8-bit value on the stack. This instruction speeds up the previous 8086 method of moving an immediate value to a register and then pushing that register on the stack to pass an immediate value as a parameter to a procedure.

If you want to save all the general registers (AX, BX, CX, DX, BP, SP, SI, and DI) at the beginning of an interrupt routine to use them in the routine, the 80186 has an instruction called PUSHA (PUSH all) to do all this storage in one instruction. Instruction POPA (POP all) does the reverse and is used at the end of the routine.

If you want to multiply by an immediate value in the 8086, you move it into a register or a memory location first and then multiply. In the 80186, instruction IMUL (integer multiply immediate) can multiply any 16-bit general register or memory location as the source with an immediate 16-bit integer (or a sign-extended 8-bit integer) and place the 16-bit product in any 16-bit general register as the destination.

For multibit shifts/rotations, you can shift or rotate by the count held in the CL register for both the 8086 and the 80186. However, the 80186 also lets you specify the count by an immediate value in the instruction (e.g., SAL BX,5).

String instructions let you manipulate blocks of memory. The 80186 has two added string instructions (INS and OUTS) for input/output devices. Instruction INS (input string) stores in memory, pointed to by the ES segment register with DI offset, the block of bytes or words input from the device whose port address is in the DX register. Instruction OUTS (output string) outputs to the device, whose port address is in the DX register, the block of bytes or words in memory pointed to by the DS segment register with SI offset. You can use these instructions with or without a REP prefix, and DI and SI are updated the same way as string instructions.

Block-structured high-level languages (such as Pascal) create a stack frame for local variables at each procedure level and copy pointers to access a previous level's variables. The 80186 instruction ENTER is used by a compiler to set this up. The first operand says how much room (in bytes) to set aside on the stack for local variable space. The second operand equals the level to determine how many pointers to copy to this procedure's stack area. Instruction ENTER also follows the convention of pushing BP and loading BP with SP. The LEAVE instruction does the opposite and has no operands.

The BOUND instruction checks the array-index register specified in the instruction against a boundary to determine whether it is within limits. The array-index register is compared with a two-word memory block whose offset is in the instruction. The first word contains the lower limit that the index register can contain, and the second word contains the upper limit. If this register is out of the boundary, an automatic interrupt type 5 is generated. Any general register can be specified, but you would usually use BX, BP, SI or DI because they are in the addressing modes.

Notice that a new interrupt type is defined by the 80186. Other interrupts are also used by the 80186 that were previously reserved for future use by the 8086. If the 80186 encounters an undefined op code, an automatic type 6 interrupt is generated. If an ESC instruction comes in and the 80186 is not connected to a coprocessor, the instruction is normally ignored. But if you want to emulate the instruction in software, you would set the bit mentioned earlier in the relocation register. Then, every time an ESC instruction comes in, an automatic type 7 interrupt is generated, and the return address will point to the ESC instruction that caused it. The routine would then emulate the ESC instruction in software by using this information. The timers, DMA channels, and external interrupts have interrupt types associated with them as well.

Building on 8086 experience, enhanced hardware functions make the 80186 a much improved microprocessor for hardware designers because of its reduced component count and interconnections. These advanced features help speed up the execution of software. The added instructions provide additional programming benefits.

Mnemonic	Description of Operation
PUSH immediate	PUSH immediate data
PUSHA	PUSH all general registers
POPA	POP all general registers
IMUL dest, source, immediate	Integer multiply immediate
Shift/rotate dest, immediate	Shift/rotate destination by immediate count value
INS	Input string using DX for port
OUTS	Output string using DX for port
ENTER stack-frame, level	Enter procedure
LEAVE	Leave procedure
BOUND reg,boundary	Check array against boundary

The 80186 has 10 additional instructions added to its 8086-based instruction set for added software capabilities.

not affect the Zero flag, you could precede these conditions with a CMP and make it a condition to fall out of the loop prematurely.

Because LOOP decrements CX first and then checks to determine whether it is zero, you could encounter problems if you enter the loop with CX equal to zero. If you don't check CX for zero before the loop, you would execute the loop 65,536 times. To prevent this problem, you employ the JCXZ (jump on CX zero) instruction. It jumps if CX is equal to zero; you could use this to jump around the loop if CX is equal to zero and you don't want to execute the loop so many times.

Procedures

Procedures, a name given to subroutines by high-level languages, are used for often repeated parts of a program. The CALL instruction is used to jump to a procedure, and the RET (return) instruction returns you back to the program. The CALL instruction is like a jump except that it saves the return address, the address of the next instruction following the CALL, on the stack; there is no short form of this instruction. The CALL instruction can be indirect or direct as well as near or far. The near-form CALL instruction places the contents of the IP register on the stack and then adds the displacement in the instruction to the IP register. The far-form CALL instruction pushes both CS and IP on the stack before reloading these registers. This means that the RET instruction must be either far or near. Once a procedure has a far return at its end, you must use a far CALL to the procedure to make sure that the right information is on the stack for the RET instruction.

Often, you need to pass information, called parameters, to procedures. These parameters can be passed in different ways. One way is to pass the parameter in a register, and the procedure would use that register's contents. Another way is to save the parameter in a memory location common to the procedure. A third way is to pass the parameters on the stack and have the procedure get them and clean up the stack after it is done. To pass parameters on the stack, you can push register contents or the contents of memory locations; this is the most common method used by high-level languages.

Reentrant procedures are those that call themselves, that call another procedure and then that procedure calls it back, or that can be interrupted and the interrupt calls the procedure. Each time the procedure is called, it might require different parameters to work with. If you use the stack to pass these parameters, then each time the procedure is called it has a new stack frame to work with, an area in the stack set aside for a procedure to work in.

Figure 3 shows an example of a calling program that pushes the parameters on the stack and the procedure that utilizes these parameters. The stack frame is also shown as it would look after the BP register is pushed on the stack in the procedure.

Remember from part 1 that the physical address consists of a segment and an offset. The 8086 addressing modes can use the contents of the BX, SI, DI, or BP registers to generate the offset to get data. The BX, SI, and DI registers default to the DS, but the BP register defaults to the SS register as its normal segment register. BP can then be used as the base register to access parameters on the stack. All procedures that have parameters on the stack then employ the BP register as shown in figure 3.

In the sample procedure, you first use PUSH to put BP on the stack to save it and thus not ruin it for another procedure that is using it. Following that, you direct BP to point to the same location as SP with the MOV BP,SP instruction. In this way, you have the BP and SP registers pointing to the same area, namely, the top of the stack. Now you can use the BP register to access the parameters off the stack frame instead of changing the contents of the SP register. Because the SP register is used to point to the top of the stack, and interrupts as well as procedures employ the stack to save the return address, you don't want to mess around with this register.

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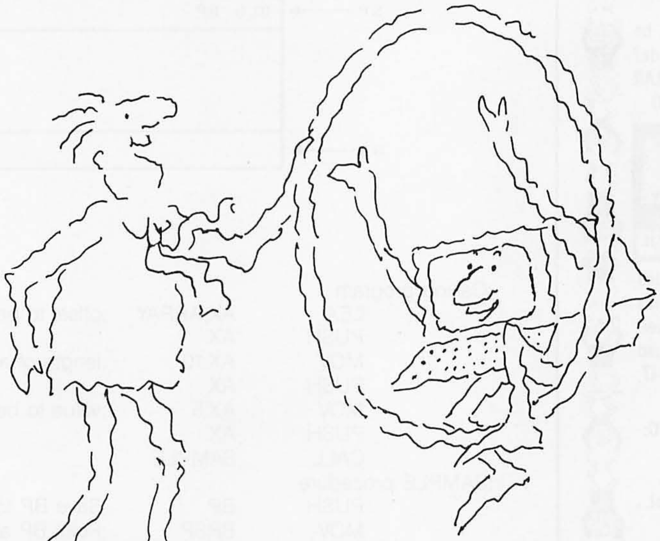

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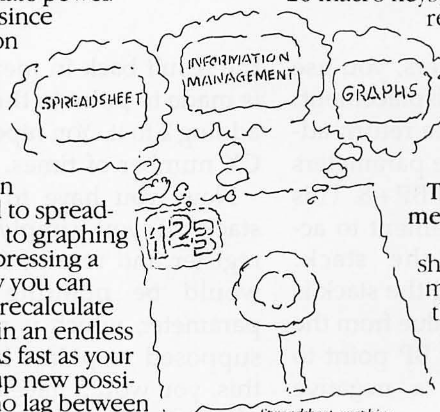

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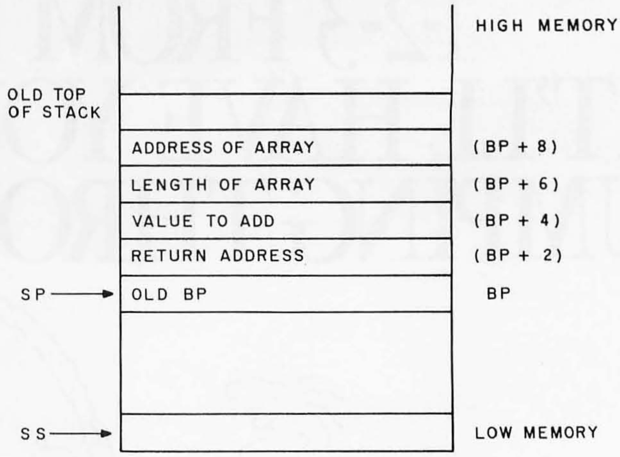


```
;Calling program
            LEA     AX,ARRAY    ;offset to beginning of array
            PUSH    AX
            MOV     AX,10       ;length of array is 16 words (10 hexadecimal)
            PUSH    AX
            MOV     AX,5        ;value to be added
            PUSH    AX
            CALL    SAMPLE
;SAMPLE procedure
            PUSH    BP          ;Save BP for protection
            MOV     BP,SP       ;Point BP at top of stack
            MOV     AX,[BP+4]   ;Get value to be added
            MOV     CX,[BP+6]   ;Get length of array
            MOV     SI,[BP+8]   ;Get offset of array
            JCXZ    STOP        ;Skip loop if CX=0
AGAIN:      ADD     [SI],AX     ;Otherwise add value in AX to array
                                ;whose offset is in SI
            ADD     SI,2        ;Have SI point to next word
            LOOP    AGAIN       ;Do this CX times
STOP:       POP     BP          ;Restore BP
            RET     6           ;Return and add 6 to SP to point at
                                ;old top of stack
```

Figure 3: *Using the BP register to access parameters.*

To access the parameters, you use the BP register plus a displacement. As shown in figure 3, the return address is at BP+2 and the parameters are at BP+4, BP+6, and BP+8. This satisfies the first requirement to access parameters on the stack. Another benefit of using the stack is that you can subtract a value from the SP register after having BP point to it. Then, if you use a negative displacement with BP, you can access this area as a workspace for your procedure's local variables.

The procedure then moves these parameters into the proper registers. Next, you check the CX register for zero so that you don't do the loop 65,536 times. In the loop, you add the contents of the location pointed to by SI with the value in AX, and place the result back in memory. Then SI is made to point to the next word by adding 2 to it. You repeat this process CX number of times.

Now, you have to clean up the stack. If you simply pop the BP register and return, the SP register would be pointing at the first parameter, which is not where it is supposed to point. If you just did this, you would have to make it part of the calling program to pop the parameters off the stack. Because a procedure can be called several times, this would involve a large amount of overhead. To clean up the stack, the RET instruction can have a value that is added to the SP register after the return address is placed back in the IP register. In the sample program, the value added to the SP register is

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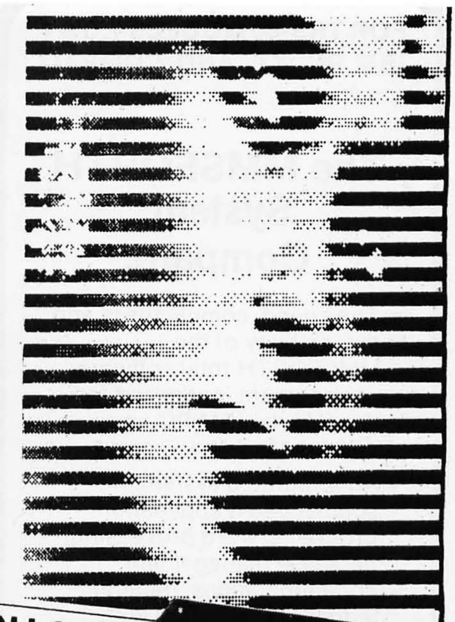

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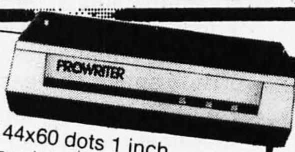

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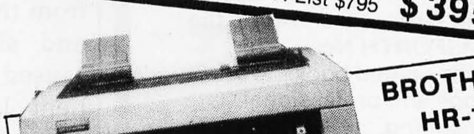

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6, which is where the old top of stack was before the parameters were pushed on the stack by the calling program.

Interrupts

The 8086 has several sources for interrupts. An interrupt can come from external devices, software instructions, or within the 8086 itself. The external sources for interrupts come from two pins called INTR (interrupt request) and NMI (nonmaskable interrupt). The INTR pin is maskable by the IE (interrupt enable) flag in the 8086 flag register. If the IE flag is set, INTR can interrupt the 8086; if the IE flag is cleared, then INTR can't interrupt. NMI cannot be masked and is used mostly to report catastrophic events such as memory-parity errors or an imminent power failure.

As listed in table 1, the software interrupts are INT (interrupt), followed by the interrupt type and INTO (interrupt on overflow). The interrupts from the 8086 itself are divide error and single-step. Divide error is caused by a division having a quotient larger than the destination register, such as division by zero or dividing a large number by 1. Single-stepping is actually an interrupt after every instruction that is caused by the TF (Trap flag) in the flag register being set.

When you receive one of these interrupts, certain events occur. If it is an external interrupt, the current instruction has to finish execution (except if it is a MOV or a POP to a segment register, then it is the instruction following the current instruction). All the interrupt types then push the contents of the flag register on the stack. After this is done, the 8086 clears the IF and TF flags. This is to prevent any INTR inputs from interrupting the processor and to prevent single-stepping through the interrupt routine. Because the flags are saved, whatever they were prior to the interrupt will be restored after the routine is finished. Next, the 8086 pushes the contents of the CS and IP registers on the stack to save the return address in the same way a far CALL does. Finally, CS and IP are loaded from an interrupt-pointer table, depending on the type of interrupt. The interrupt-pointer table is a reserved area of memory that occupies the first 1K bytes of memory space, as shown in figure 4.

Notice that certain interrupts have reserved pointers for them and can generate those types automatically when they occur. Divide error is type 0, single-step is type 1, nonmaskable interrupt is type 2, breakpoint is type 3, and overflow is type 4. In addition, types 5 through 31 are reserved by Intel for future use and should not be used at this time. The others are available for use by the INTR or INT instructions. For INTR, an external device supplies the type, and the INT instruction supplies the type in the instruction. The 8086 takes the type of interrupt, multiplies it by 4 to get to the correct table entry, and then loads it into the CS and IP registers. These table entries must be filled by you with the starting segment and offset of your particular interrupt routine. In other words, if you plan to include any divide instructions in your programs and you don't check the operands, you should fill the pointers at addresses 0 through 3 with the CS and IP values of a routine to handle a divide error.

The interrupt routine should save any register used by it because you don't know when the interrupt occurred for an external interrupt, and you wouldn't want to destroy anything that you might have in these registers. An IRET instruction should reside at the end of the interrupt. This instruction performs almost the same operation as a far-RET instruction, but it also pops the flags back.

The INT instruction can check out interrupt-service routines by having the INT instruction followed by the type number of the one to be checked or used. For example, the divide-error routine might be the same as a routine needed in your program. The INT instruction can also be used for calls to another program to service particular devices. Because the code can be located anywhere in memory, but the interrupt-pointer table is at a fixed location, this makes it convenient to use for this purpose.

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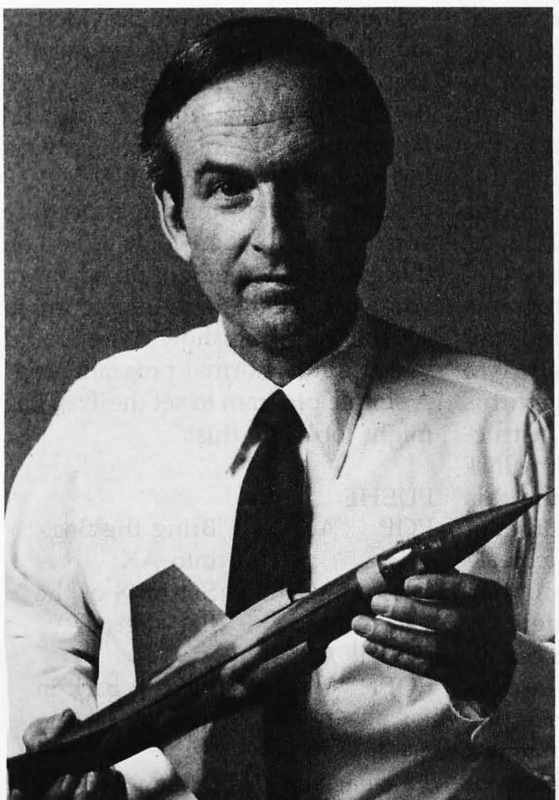

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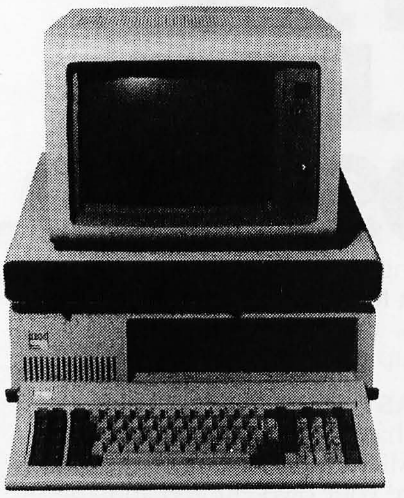

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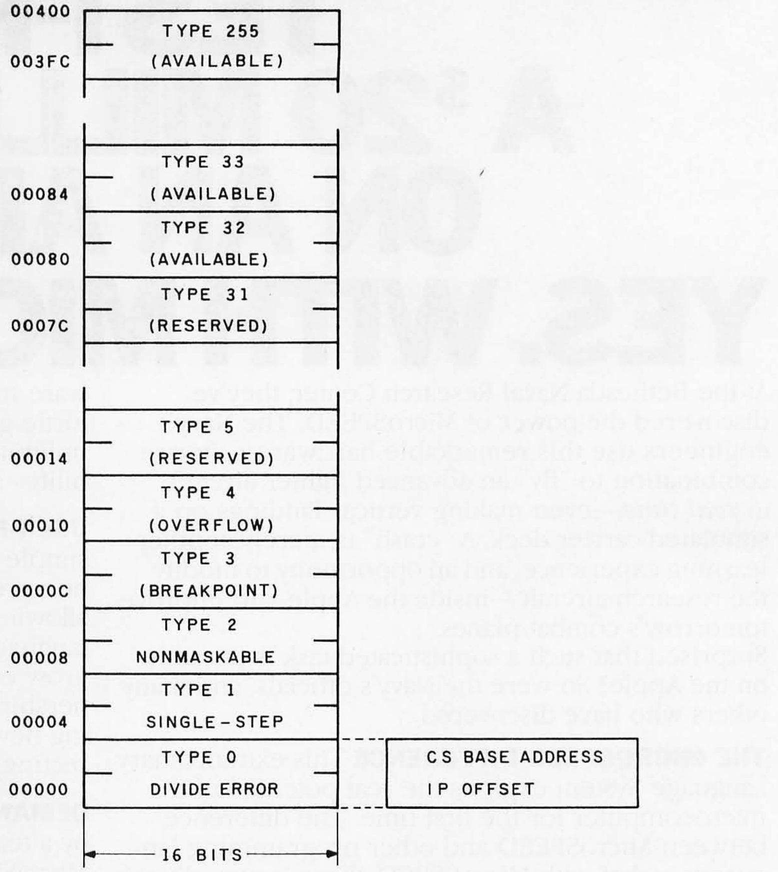

Figure 4: *The interrupt-pointer table reserves the first 1K bytes of memory space. Each type of interrupt contains two words, which point to the segment and the offset of the interrupt routine that handles that type.*

The INTO instruction is a conditional interrupt on the Overflow flag. This instruction generates a type 4 interrupt if the Overflow flag is set. Otherwise, control is passed to the next instruction. You could use this instruction after an arithmetic or logic instruction as a conditional CALL on the Overflow flag.

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The other operation provided to aid debugging involves setting the Trap flag in the flag register. When the Trap flag is set, the 8086 does an automatic type 1 interrupt after each instruction, except on a MOV or POP to a segment register. The procedure you write can then look at certain things, display them, or do whatever you want. There is no instruction to set the Trap flag; how often would you use it in normal programming? A simple program to set the Trap flag might look like this:

```
PUSHF
POP    AX          ;Bring the flags
                   ;into AX
OR     AX,0100     ;Set bit 8 of the
                   ;flag register
PUSH   AX
POPF               ;Place it back in
                   ;the flag register
```

To clear the Trap flag, you could replace the OR instruction with an

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Mnemonic	Description of Operation
MOVSB/MOVSW	Move byte or word string
CMPSB/CMPSW	Compare byte or word string
SCASB/SCASW	Scan byte or word string
LODSB/LODSW	Load byte or word string
STOSB/STOSW	Store byte or word string
REP	Repeat
REPE/REPZ	Repeat while equal/repeat while zero
REPNE/REPNZ	Repeat while not equal/repeat while not zero

Table 3: *The string instructions let you work with blocks of data using 1-byte instructions.*

Register or Flag	How Contents Are Used
SI	Index (offset) for source string
DI	Index (offset) for destination string
ES	Segment of destination string
CX	Repetition counter
AL/AX	Scan value Destination for LODS Source for STOS
DF	0 = auto-increment SI,DI 1 = auto-decrement SI,DI
ZF	Scan/compare terminator

Table 4: *The string instructions use dedicated registers to generate fewer instructions, and they are shorter (1 byte) in length.*

AND AX,FEFF.

String Instructions

At times, you need to manipulate large blocks of data in memory, such as moving them from one location to another, searching for a particular value, etc. You could accomplish this with the instructions shown in figure 5's first program. In program 1, you load the SI register with the offset of the block you wish to move, the DI register with the offset of where you wish to move it to, and the CX register with the number of bytes you wish to move. The actual move requires loading the word using SI and saving the word using DI. Then you move the pointers to the next word and loop back and repeat it. This accomplishes the tasks you set out to do but requires several instructions and extra time to perform them.

Instead, string instructions, as shown in table 3, could be used to solve this problem. They can do byte or word operations and are actually short (1-byte) instructions. They use dedicated registers, as shown in table

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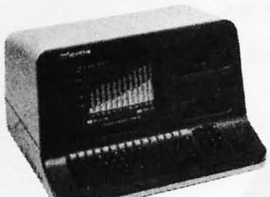

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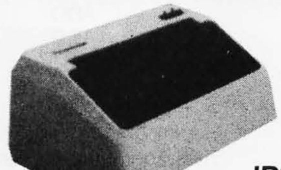

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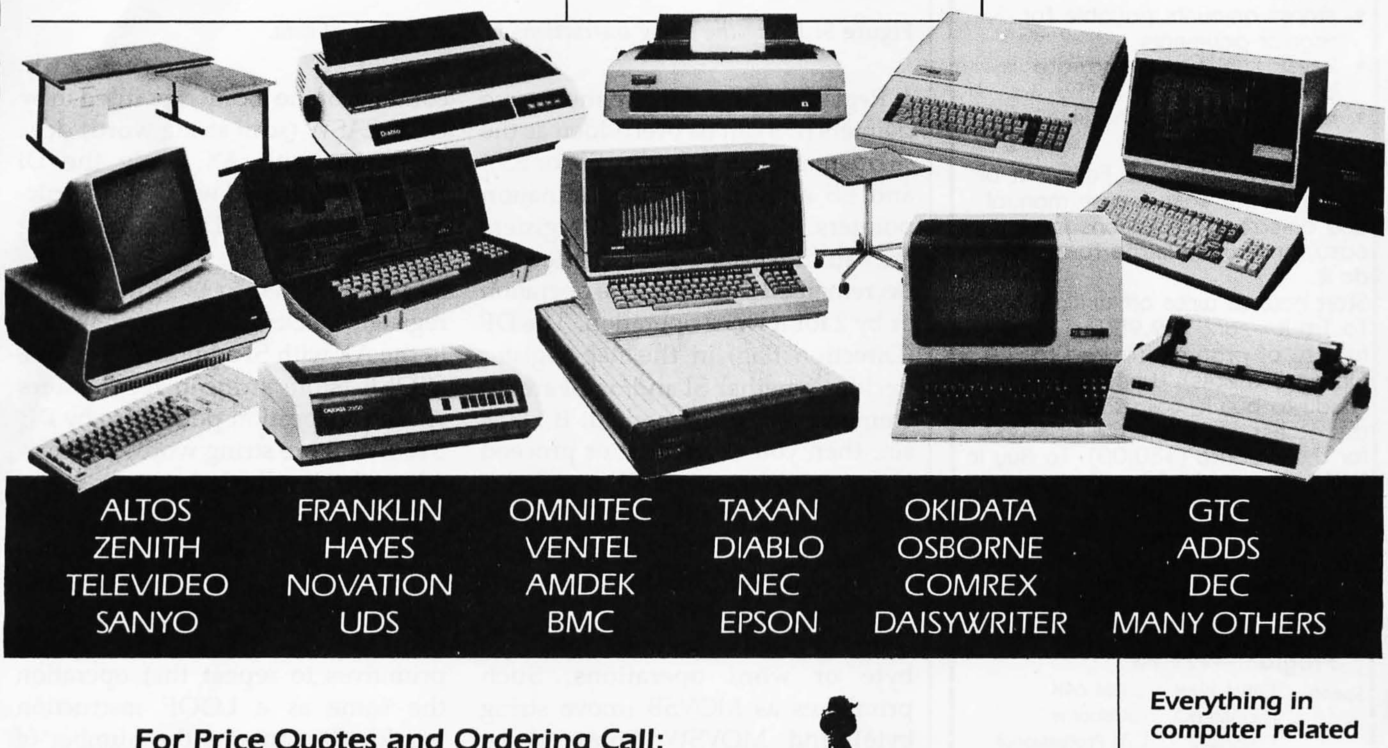

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Program #1

```
;This program will move a block beginning at BLOCK1 to a block
;beginning at BLOCK2. The DS register is pointing at the
;segment that contains these blocks. Each block is 80 words
;long (50 hexadecimal)

          LEA     SI,BLOCK1    ;Get the blocks offsets in
          LEA     DI,BLOCK2    ;the index registers
          MOV     CX,0050      ;Number of words to move (80 decimal)
AGAIN:    MOV     AX,[SI]      ;Bring in from BLOCK1
          MOV     [DI],AX      ;Save this word to BLOCK2
          ADD     SI,2         ;Move pointers to next word
          ADD     DI,2
          LOOP    AGAIN        ;Using CX as a counter to do 80 times
```

Program #2

```
;This program is the same as the first except the string
;instruction MOVSW is used and AX is not destroyed

          PUSH    DS           ;Make ES point to the same segment
          POP     ES           ;as DS to use as destination
          LEA     SI,BLOCK1
          LEA     DI,BLOCK2
          MOV     CX,0050
          CLD                  ;Set up auto-increment of SI and DI
REP       MOVSW                ;Same as AGAIN loop except AX is
                               ;not affected
```

Figure 5: *Using the string instructions to move a block of data.*

4. Registers DS and SI are the source pointers (DS can be overridden as the segment register to be CS, ES, or SS), and ES and DI are the destination pointers. The SI and/or DI registers are automatically incremented or decremented by 1 for a byte operation or by 2 for a word operation. The DF (Direction flag) in the flag register decides whether SI and/or DI are incremented or decremented. If DF is set, then you decrement or proceed to lower addresses; if DF is cleared, then you increment. The DF can be set by the STD (set direction) instruction and cleared by the CLD (clear direction) instruction.

String primitives perform single byte or word operations. Such primitives as MOVSB (move string byte) and MOVSW (move string word) transfer the contents of the location pointed to by SI to the location pointed to by DI with SI and DI adjusted. Primitives CMPSB (compare string byte) and CMPSW (compare string word) compare the contents of the location pointed to by SI with the contents of the location pointed to by DI with SI and DI adjusted, which affect the flags the same as a CMP instruction. Primitive SCASB (scan string byte) compares the contents of the AL register to the contents of the location pointed to by DI; SCASW (scan string word) does the same with AX. Only the DI register is adjusted with this instruction. Primitive LODSB (load string byte) transfers the contents of the location pointed to by SI to the AL register; LODSW (load string word), to the AX with SI adjusted. Primitive STOSB (store string byte) transfers AL to the location pointed to by DI; STOSW (store string word) transfers AX with DI adjusted.

To do block operations, you can place a 1-byte prefix in front of a string primitive called a REP (repeat) prefix. You would use REP in front of the MOVS, STOS, or LODS primitives to repeat that operation the same as a LOOP instruction would. CX contains the number of MOVS, STOS, or LODS operations you want to do with a REP prefix. As shown in figure 5, MOVSW with a REP prefix accomplishes in program 2 the same task done in program 1. Notice that the ES register is initialized and the Direction flag is cleared for auto increment. Using REP before a STOS instruction lets you *initialize* a block of memory with a certain value, such as a zero to clear a block of memory. However, REP would probably not be used before a LODS

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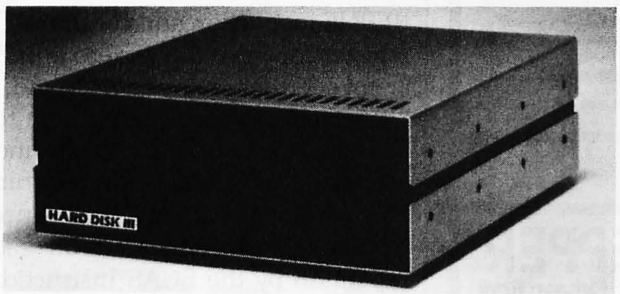

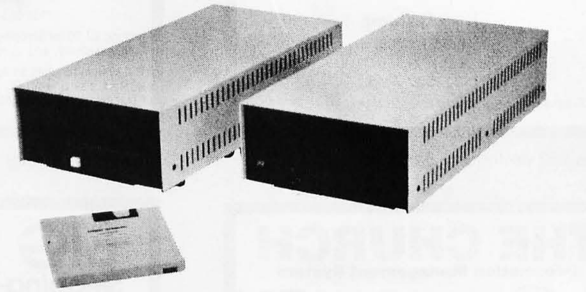

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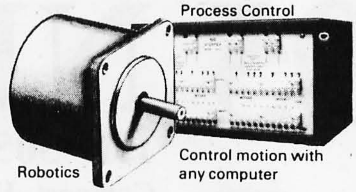

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instruction.

For the CMPS and SCAS instructions, you have the conditional REP prefixes of REPZ/REPE for repeat while zero/repeat while equal and REPNZ/REPNE for the opposite condition. These are similar to the conditional LOOP instructions. For example, if you use the REPNE in front of the SCASB instruction, you will stop repeating if CX equals zero or if a match is found between the AL register and the location pointed to by the DI register. You could use the REPNE instruction and check the CX register for zero. If it is zero and ZF is not set, then no match is found. If CX is not zero or ZF is set, then the DI register is pointing to the location following or before the matching character, because it is auto-decremented/incremented on each repetition by the SCAS instruction. A program demonstrating this setup is shown in figure 6.

With a repeat prefix, CX is checked for zero before the operation, which is different from the LOOP instruction. This means that you don't have to precede the repeated string operation with a JCXZ to prevent doing it 65,536 times. Another interesting point is that an interrupt can be recognized during a repeated string operation at each repetition. These are the only instructions that allow interrupts during execution because using a REP might tie up the 8086 for a long period of time.

Primitives also permit you to build your own string operations. For example, you could translate an entire block of memory from one code to another after the registers are set up correctly:

```
AGAIN: LODSB
       XLAT
       STOSB
       LOOP    AGAIN
```

Processor-Control Instructions

Processor-control instructions let programs control various 8086 functions, as shown in table 5. The STC (set carry), CLC (clear carry), and CMC (complement carry) instructions affect the Carry flag. Instructions STD and CLD are explained in

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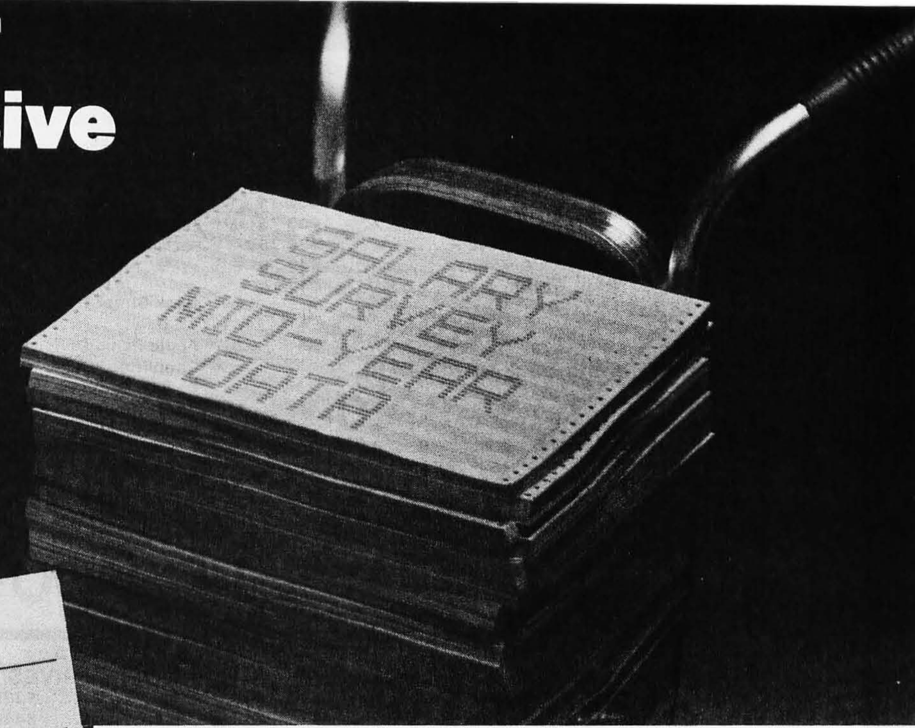

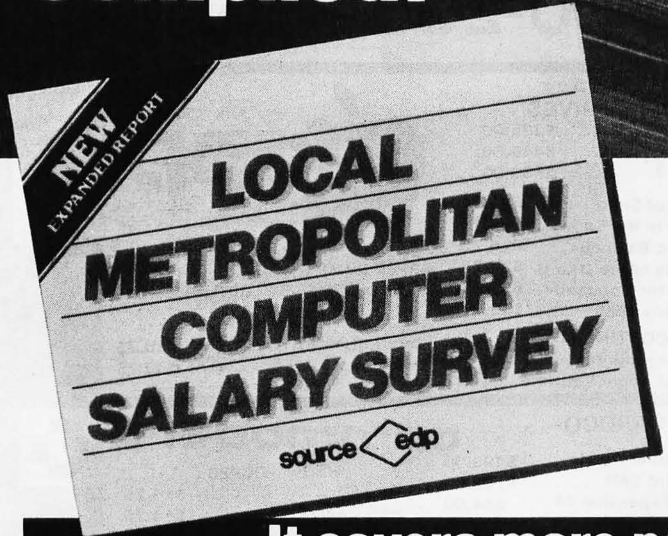

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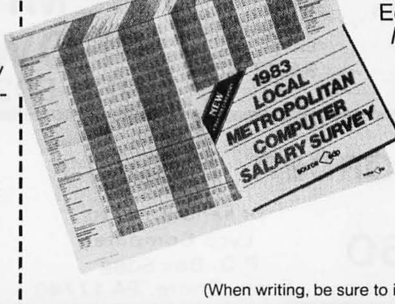

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```
;This procedure scans a buffer for a particular byte
;character and replaces it with another character. The
;parameters are passed in this order:
;The segment of the buffer
;The offset of the buffer
;The number of bytes to scan for
;A word whose low byte is the character to search for and
;whose high byte is the character to replace with

          PUSH   BP
          MOV    BP,SP
          LES    DI,[BP+8]          ;Get segment in ES and offset in
                                    ;DI using a double word in the
                                    ;stack (may have to tell assembler
                                    ;by LES DI,DWORD PTR[BP+8] )
          MOV    CX,[BP+6]          ;Length to search for
          MOV    AX,[BP+4]          ;AL contains character to search
                                    ;for and AH has character to
                                    ;replace with
          CLD                       ;Auto-increment
SEARCH:   REPNE  SCASB              ;Scan buffer until AL matches
          JE     SWAP               ;If a match swap the characters
          JMP    Done               ;otherwise stop
SWAP:     MOV    ES:[DI-1],AH       ;Using DI with a -1 displacement
                                    ;because SCAS does an increment of
                                    ;DI, transfer the new character
                                    ;making sure to use ES (and not
                                    ;DS) as the segment register
          JCXZ   DONE               ;In case the last match was also
                                    ;at the end of the buffer
          JMP    SEARCH
DONE:     POP    BP
          RET    8
```

Figure 6: *Scanning a buffer for a particular byte and replacing it with another character.*

Mnemonic	Description of Operation
STC	Set Carry flag
CLC	Clear Carry flag
CMC	Complement Carry flag
STD	Set Direction flag
CLD	Clear Direction flag
STI	Set Interrupt-Enable flag
CLI	Clear Interrupt-Enable flag
HLT	Halt until interrupted or reset
WAIT	Wait for TEST pin active
ESC	Escape to external processor
LOCK	Lock bus during next instruction
NOP	No operation

Table 5: *Processor-control instructions direct various 8086 functions.*

the section on string instructions.

The CLI (clear interrupt) instruction disables the INTR signal from interrupting the 8086 by clearing the Interrupt flag. The STI (set interrupt) lets you recognize the INTR signal after the instruction following STI has been executed.

The HLT (halt) instruction stops the 8086 until either a reset or an external interrupt on NMI or INTR occurs. When an interrupt routine returns, the 8086 resumes execution with the instruction following HLT.

Systems often use multiple microprocessors. Using more than one microprocessor results in increased system performance. The 8086 is designed to cooperate with other microprocessors via its hardware and software structures.

A special type of microprocessor, called a coprocessor, might share a program with the 8086, executing only the instructions pertaining to it and ignoring the 8086 instructions. For example, the 8087 coprocessor, a numerics data processor, performs floating-point and trigonometric functions. However, the 8086 must

know that an instruction coming in is for the coprocessor and not for itself. Therefore, coprocessor instructions are contained in an ESC (escape) instruction, which the 8086 will ignore. The coprocessor monitors the bus and, when an ESC comes in, captures its op code from the ESC instruction. If an operand from memory is involved, the 8086 fetches that operand (calculating the address) and discards it. The coprocessor can capture the operand or the address at this time from the bus as well; the 8086 then goes on to the next instruction while the coprocessor is executing this instruction.

Because a coprocessor might take a different time period to execute its instruction, there should be some coordination between the two processors. Before another coprocessor instruction comes in, the coprocessor should finish its current one. A pin on the 8086, called TEST, accomplishes this mission. The WAIT instruction looks at this pin and, if the pin is LOW, the 8086 will go on to the next instruction. But if the pin is HIGH, the 8086 will enter a wait condition. Therefore, the coprocessor can pull this pin HIGH until it is finished with its instruction. Most ESC instructions, and any 8086 instruction that looks at a coprocessor's results, should be preceded with a WAIT instruction.

Although multiprocessors can share memory and input/output devices, they must have their own programs. Often, they utilize the same buses to access common devices and take turns using this bus. Sharing, then, might involve some communication between multiprocessors. For example, microprocessor #1 could be filling a block of memory with new data while microprocessor #2 is reading that same block of memory. Without some notification, microprocessor #2 might get part of some old data and part of some new data.

The most common method of sharing a block of memory is to set up one location as a flag to let each processor know that this block is in use. Therefore, each microprocessor

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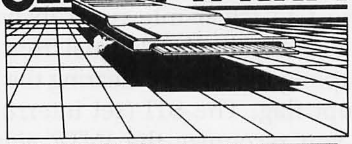
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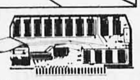
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agrees that if this location contains a hexadecimal 01, the block is in use. The microprocessor must then set it to 1 if it is using that block when the flag is clear. A simple method is to move a 1 into the AL register and exchange the AL register with this flag location. If after this exchange AL is still a 1, then you know that the block is being used by another processor. But if AL is zero, then the microprocessor can use this block, and the flag location is already set to 1 by the XCHG instruction.

However, there is one problem with this setup. The microprocessor must use the bus twice to do the XCHG instruction; once to read the memory contents and once to write the contents of the AL register in this location. However, in between these operations another processor might get in there and do the same thing, and you once again have the same problem. The 8086 has provided a prefix called LOCK in its instruction set. Any instruction preceded by the LOCK prefix gains total control of the bus for the entire instruction; no other processor can gain bus use until that instruction is done. This instruction affects one 8086 pin, called LOCK, which causes the hardware to lock the bus.

Conclusion

You have perceived the many advantages that the 8086 offers programmers. Its addressing lets you access many types of operands for your instructions and accommodates different types of program development. The instruction set is versatile, and added operations make the programming task easier. The 8086 supports high-level languages with memory-based variables and produces compact code.

I hope that this series of three articles will help you when you work with the 8086, whether you are programming it or debugging its listings.■

Stephen Heywood is an instructor with Intel Customer Training and is involved with preparation of the 8086 course. He can be contacted at Intel Corporation, 27 Industrial Ave., Chelmsford, MA 01824.

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Book Reviews

CBASIC User Guide

Adam Osborne, Gordon Eubanks Jr., and Martin McNiff
Osborne/McGraw-Hill
1981; 214 pages
softcover, $16.95

Reviewed by
Dr. Bruce R. Evans

"The CBASIC language may be the most advanced version of BASIC yet created."

Adam Osborne never was wishy-washy! Don't, however, let this outrageous quotation from the cover of *CBASIC User Guide* put you off. CBASIC *is* a super language, with lots of business software written in it. If you are going to modify any of these programs or write your own, you need this book.

Much of the book's information is included in the documentation that comes with CBASIC, but the CBASIC manual is poorly written, edited, and printed. Not so with the *CBASIC User Guide*. As an example, six pages of error messages, their causes, and program responses to them tell more than the reference manual's ten pages. For this reason alone, any CBASIC programmer needs this book close by.

This book is more than a reference. Rather than dole out a single line demonstrating each command, the authors illustrate commands in the context of entire subroutines. Their discussion of the differences between and uses of WHILE. . .WEND and FOR. . .NEXT loops opened my eyes. In your BASIC, does a dimensioned variable start with the subscript 0 or 1? My manual doesn't mention this, but the *CBASIC User Guide* not only does but further explains how this can affect memory size. CBASIC supports compound IF statements, but I wouldn't have known this from the manual—score another plus for this book, which tells me about this.

This book is filled with meticulously written short programs that you should enter and run. By doing this, you can feel the language, get used to good programming style, and learn useful concepts without realizing it.

A few programs are not so short: the authors go into a great deal of detail about the video display input and output of programs. Here is an area in which many experienced computer users have a blind spot. The authors reminded me that, not only do most business users of personal computers not know the things programmers take for granted about the use of personal computers—how to signal the end of input by hitting the Return key, how to format their response to an INPUT statement—they are actually afraid of the machines. This makes programs that are fault-tolerant and easy to use a necessity. They also remind us that CBASIC programs should be made to run correctly on terminals that use different commands to manipulate the video display.

By itself, chapter 11 on file structure makes the book invaluable. What files are about, how they are arranged, and how we affect them are all fully discussed here. The chapter also talks about the dangers of leaving files unclosed, how this can accidentally happen (such as by inputting Control-Z), and how to program around these problems. Seven sample programs give a feel for handling sequential and random-access files. If you are not comfortable with files after reading this chapter, you never will be. Again, the basic information is available in the CBASIC manual, but it's not well explained there.

Does this book have any failings? Yes, it does have a few. The title is misleading. It should be *CBASIC Version 2 User Guide*. Because of significant differences between version CBASIC 2.*x* and earlier versions, you should not use this book if you have an earlier version.

A strong point of CBASIC is that it allows 31-letter variables; a weak point of this book is that the authors tend to use all 31 letters in their examples. To the uninitiated, it is confusing to see examples that use such variables as THIRTY.DAY.MONTH% or a line such as

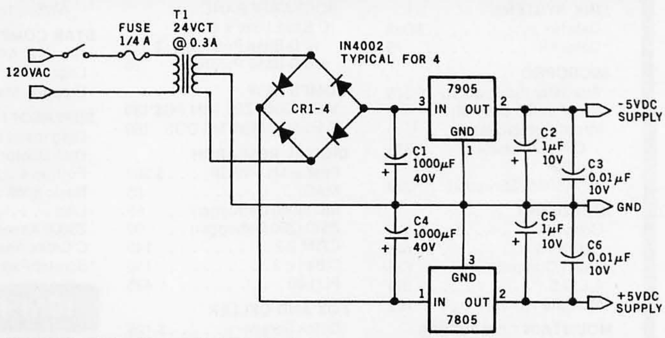
```
MTD.PAY=MTD.PAY+
  FN.NEAREST.CENT
  (NETPAY)
```

Although long variable names are invaluable in documenting a program, they are needless complexities when illustrating the programming language itself. Finally, was it really necessary to include six pages of hexadecimal-decimal conversion charts at the end? This leaves the reader wondering if the writer is paid by the page!

The *CBASIC User Guide* is produced in the tradition of all Osborne books. It is well written, well printed, and high priced. I think the first two features justify the third. I recommend this book to anyone using CBASIC and even more to anyone who isn't using it yet. ■

Bruce Evans is a family physician with a hobby interest in electronic computing who practices in Toronto. He can be reached at 16 Marwin Rd., Pickering, Ontario, L1V 2N7 Canada.

BYTE's Bugs



Bad Resolution in Power Supply

A drafting error marred the System Notes article "A High-Resolution Analog-to-Digital Converter for the TRS-80" by James Cameron (February 1983 BYTE, page 378). The schematic diagram of the suggested power supply, shown in figure 2 on page 384, contained a reversed set of pin numbers for the 7905 voltage regulator. Furthermore, the capacitors were not properly specified and some of their polarities were reversed.

For the benefit of our readers who may want to build that power supply, the corrected circuit is shown here above. Our apologies to those of you who were inconvenienced.

Our thanks to Michael H. Butler of Beltsville, Maryland, and others for pointing out the problems. ■

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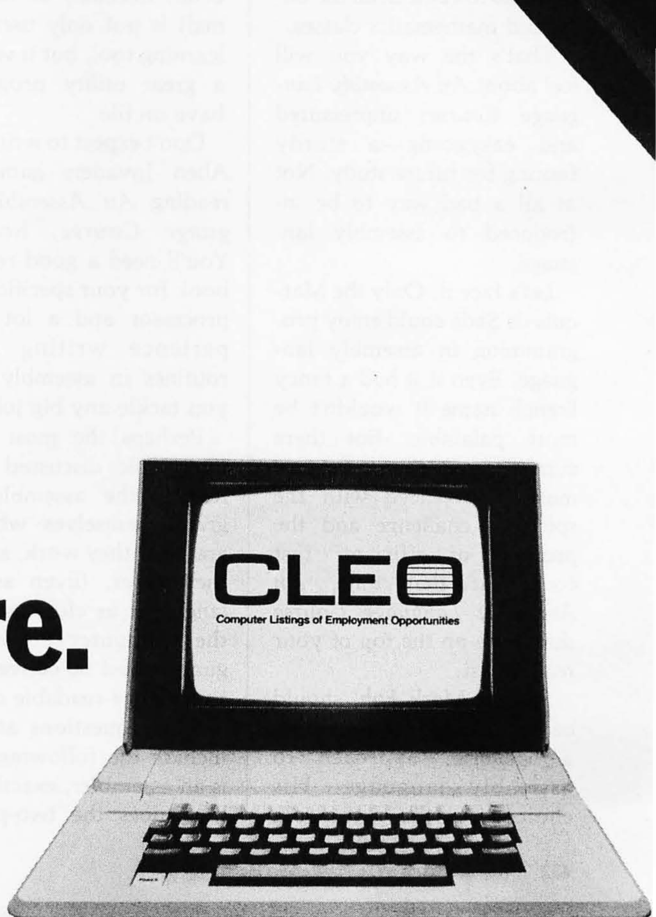

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Book Reviews

An Assembly Language Course

Mark Fohl
Petrocelli
1982; 169 pages
hardcover, $17.50

Reviewed by
Tim Kilby

Remember sweet Miss Fenwick, your eighth-grade math teacher? When you left her class you really felt you had learned something. She knew just how to explain all the details. You weren't forced to memorize; you learned to reason out solutions to problems. And she offered fun extras that helped you get the broad picture of what math was all about. Looking back, you remember that you didn't feel pressured in her class; eighth-grade math wasn't really heavy stuff to learn when it was explained properly. You were building a foundation for everything that was to come in all the advanced mathematics classes.

That's the way you will feel about *An Assembly Language Course*: unpressured and easygoing—a sturdy footing for future study. Not at all a bad way to be introduced to assembly language.

Let's face it. Only the Marquis de Sade could enjoy programming in assembly language. Even if it had a fancy French name it wouldn't be more palatable. But there comes a time when resistance must be replaced with the spirit of challenge and the promise of efficient, fast code. At that time, *An Assembly Language Course* should be on the top of your reading list.

Author Mark Fohl should be commended for providing a "generic" approach to assembly language. His choice of the Motorola MC6800 microprocessor and its instruction set should not alienate users of other microprocessors. In fact, those of you with other computers (myself included; I have the 6502) will benefit greatly by his instruction. Because I was not expecting to be a full-fledged assembly programmer by the last chapter, I was able to concentrate on principles, logic, and operations.

There is a laconic discussion of the 6800 architecture and instruction set, which you will find valuable in studying your microprocessor's structure. While not confusing the reader with instruction sets of other processors, Fohl does suggest similarities to look for. His first-class explanation of the binary number system, as it is used in assembly language, is excellent reading for novices trying to understand how computers work. And a short source-code listing of a radix-converter routine (binary, octal, decimal, or hexadecimal) is not only useful as a learning tool, but it would be a great utility program to have on file.

Don't expect to write a new Alien Invaders game after reading *An Assembly Language Course*, however. You'll need a good reference book for your specific microprocessor and a lot of experience writing simple routines in assembly before you tackle any big jobs.

Perhaps the most important topic discussed in the text is the assembler programs themselves: what they are, how they work, and how they differ. (Even assembly language, as close as it is to the computer's own language, must be converted into machine-readable code.)

Other questions answered include the following. What is an assembler, exactly? And how does the two-pass assembler affect the readability of source code? When are cross-assemblers and macro assemblers preferred? Why would you want an assembler capable of conditional or relocatable assemblies? All these issues are discussed for the reader's complete understanding of the assembly-language process.

I can by no means be considered an experienced assembly-language programmer. I've learned by necessity to write subroutines that will speed my BASIC programs or do tricks otherwise unattainable. By spending many hours poring through reference books, by reading what assembly source code I could get my hands on, and by annoying knowledgeable friends, I have learned what I need.

I would have had it much easier if I had just possessed *An Assembly Language Course*. Then those pseudo-ops and addressing modes, and the LDAs, CLCs, BNEs, and JMPs, would not have been so confusing. And I would not have had to stare blankly so often at the person telling me about the latest such-and-such macro assembler.

Assembly language need not be as punishing as all that for you. Many of you may take to assembly coding quicker than a dog takes to its bark. Fohl's book may even be too light for a few of you. For almost everyone, though, it should prove to be a tasty first course in a promising feast.

Miss Fenwick knew the most efficient way to get you thinking for yourself. She made sure you had the solid background you needed. Ever since that class you've been glad for having her as your teacher. Think of *An Assembly Language Course* that way. It's not the complete picture of assembly language—no book is, nor should be. It just sets the stage with efficient and concise explanations. Miss Fenwick would approve.■

Tim Kilby is a microcomputer programmer and computer consultant. His article "Character Editor for the Atari" appeared in the December 1982 BYTE. He can be reached at RR 1, Box 288-B, Sperryville, VA 22740.

BYTE's Bugs

Faulty Philosophy

In trying out the 32-bit multiply program in Thomas Starnes's article "Design Philosophy Behind Motorola's MC68000," Robert Delaney found a bug. (See the May 1983 BYTE, p. 342.)

In listing 1, the instruction ADDQ #4,A7, which appears as the second to last instruction on page 358, should be deleted. It causes an incorrect result and does not allow restoration of the stack pointer to its entry value upon completion of the last instruction.

Breakout Box Broken

Two circuits using the LM324 op amp in Steve Ciarcia's "Build an RS-232C Breakout Box" will not work properly in their present configuration. (See figure 3, page 38, and figure 4b, page 41, in the April 1983 BYTE.) Reversing the input connections will correct this drafting error.

Our thanks to Harold Balyoz in Flagstaff, Arizona, for spotting this mistake.■

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Significant subjects are surveyed by our sagacious savant

by Jerry Pournelle

They say April is the cruelest month. It certainly was for me. April began with a trip to Houston for the L-5 Society Space Development Convention. I went directly from Houston to Ithaca, New York, where I delivered the C. P. Snow Memorial Lecture; from there to New York City to see agents and editors; direct (well, it was supposed to be direct until United Airlines managed some interesting routing) from NYC to Santa Cruz for a conference of anthropologists and science-fiction writers; back home in time to do my taxes; and north for a week in Washington state, where several scenes from our next book are set. Somewhere along the way I threw my back out.

Withal I managed to play about with the Epson QX-10 computer; we have CP/M-68K for the Sage; and there's a nifty new terminal from Heath/Zenith. I even managed to answer some mail, although, alas, not all I would like to have dealt with.

The Epson QX-10

The Epson QX-10 is now available, and I'm told it's selling well. It comes in two models: with a fairly standard keyboard that has a number of special-function keys marked in the usual manner and with the HASCI keyboard designed by Chris Rutkowski of Rising Star Industries. The "standard" keyboard model comes with CP/M software; the HASCI model comes with Rising Star's Valdocs software package. You're also supposed to get a disk with the CP/M operating system. I don't have that yet. By the time you read this, however, it will surely be included with any package you could buy.

First the machine itself: I love it. The Epson QX-10 is compact and handsome enough that my wife will even allow it in the living room. The keyboard is very nice. It's missing some keys, such as tilde and curly braces { ~ ~ }, but there are ways to make it produce them.

The keyboard is very typewriter-like; it even preserves some annoying typewriter features. For example, the Shift Lock is not an "alpha lock" but a true shift lock: it puts the numbers and punctuation marks in uppercase. Also, it falls out of Shift Lock when you hit the Shift key. These are features, not bugs, according to Epson: it wants the machine to be so much like a typewriter that anyone familiar with one will be able to use the QX-10 without any adjustments.

The QX-10 has many nifty features. Little lights on certain keys, such as Insert and Shift Lock, tell you what mode you're in. When you first power up the Epson, it goes through a series of internal checks (not described in the manuals I have, so I can't say precisely what) that flash all the lights in sequence.

The screen is pretty. The character set is nice, and a single keystroke lets you put in **boldface** and *italic* text that actually look like **boldface** and *italic* on screen. In other words, there's just a *lot* to like about the Epson QX-10.

Alas, there are also things to dislike. Not about the hardware; if the Epson has any hardware problems, I'm not aware of them. I've never had a hardware problem with the machine, and I'm very fond of its little half-height 5¼-inch double-sided double-density disks.

The problems are in the Valdocs software.

Valdocs is an enhanced text editor intended for the absolute novice user. You can do just about anything you like from within the editor; it's like an operating system. For example, there's a full four-function calculator with memory; the results can be put into your document. You can also use the Calculator mode to sum up columns of numbers; I used it to prepare my expense accounts for my April trips. Like Wordstar, there's provision for running specific outside programs: I presume that one of these days there'll be things like spelling checkers, footnotes, and the like.

The Valdocs system is *very* easy to

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learn. You don't have to open a single document. You just start using it, and soon you can type letters and such like. Online help is available at all times, and a big Undo key will pretty well cancel anything you just did and don't like.

There are a number of other helpful features. There's a communications system that's supposed to work with an optional modem; I don't have that, so I can't say how well it works, but from the description it sounds pretty good. The mail management system also includes a "card file" system that lets you keep names, addresses, and telephone numbers, and get at them from inside the text editor.

The Valdocs system creates a kind of database with multiple index entries for each file you've saved, so that it can display your file directory in a number of ways: sequential, alphabetical, or, because you can have multiple-word file names, as a cross-indexed directory listing.

The system has a Schedule function that keeps track of dates and appointments in an electronic datebook. That too is accessible from within the text editor.

In other words, Valdocs is really splendid in conception, being a lot of what I've always wanted. The trouble is, you pay a high price for all these features.

The first problem is obvious from the other side of the room. The Valdocs system is *slow*. It seems to take forever to do disk operations. There's a reason, of course: when Valdocs saves a file, it makes entries in a whole series of indexes. This is all to the good, but it can be maddening.

I've been taught that when you do creative writing on a computer, the first rule is "Save Early And Often." There could be a power failure. Some fiend could pull the power cord. The computer could ingest a moth. *Anything* can happen, and unless you've saved that text from memory to disk, when something does happen, that text is *gone*.

The obvious way to save a file in Valdocs is to use the Store key, but that takes *forever*, after which you're in an empty buffer. You have to reload your file in order to continue working on it. It took me much more than a minute to save a one-page memo, then retrieve it to continue working. When you consider that I'm likely to save a long article such as this one 10 times an hour, and that it would take more than 2 minutes for each save, you can see I just can't do that.

There's another way to save your work: press the Copy Disk key, wait about 15 seconds, and press the Undo key. This stores your work in a temporary workfile that will automatically be accessed the next time you turn the machine on—a neat feature, and certainly a guard against power failures.

The trouble is that it hasn't made any backup file. If you want a backup file, you have to use the Store system. You'd also have to use a different file name.

When you do a save with Wordstar, WRITE, Magic Wand, and most other editors I'm familiar with, certain safe-

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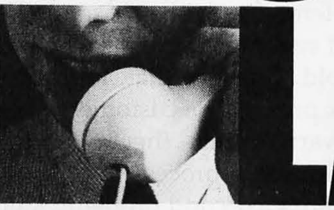

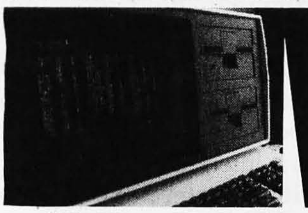

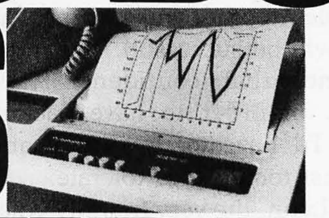

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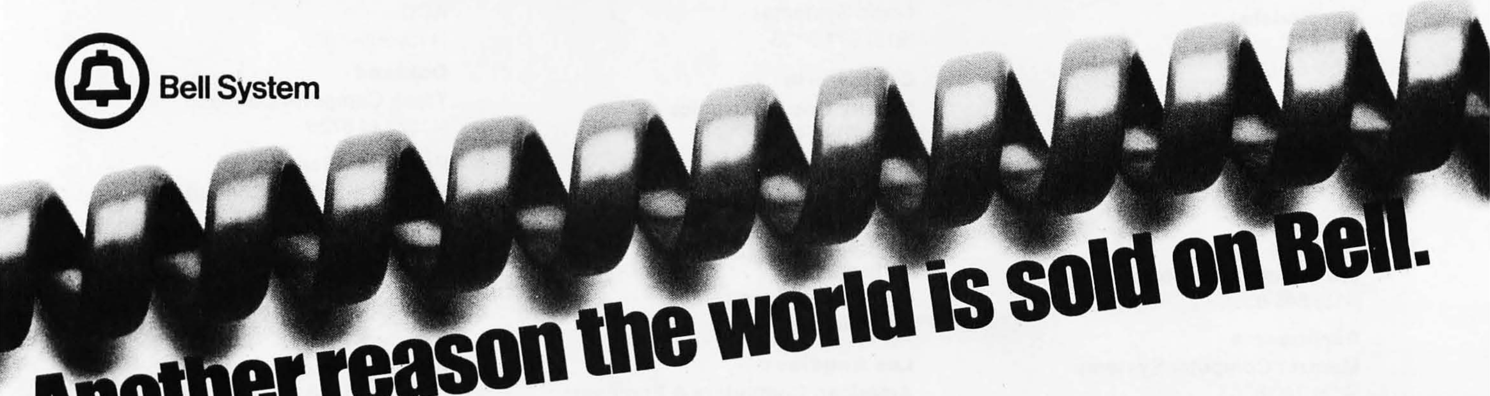

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ty measures happen. Assume you save your text as FOOFILE.TXT. If you've previously saved that file, the disk will contain a file named FOOFILE.BAK (or .BAC). Now you save again. The system saves your file as FOOFILE.$$$ (or some other temporary name), and only after a successful save and verify does it erase FOOFILE.BAK, rename the old .TXT file to .BAK, and name the new file .TXT. If there's some disaster (power failure, really screwed-up sector on the disk, whatever) during the save, you've still got copies of your work.

Valdocs doesn't do that. If you use the Copy-Undo save, or if you Store and don't give the file a new name, it writes over your only previous copy of the file: in other words, it bets all that it will be successful.

I'm not that confident. Alas, though, in order to have backup copies, I'd have to use Store, and that's just too slow to tolerate.

Joyce Lynn, the very friendly voice of Epson's hot line, tells me Rising Star is working on the problem and should have some new and faster software by next fall. Indeed, every time I pointed out problems in the Valdocs software, I was told that they'd fix it; that this is an evolving program, and when they get all the problems fixed, they'll send the revised system to everyone who bought the old. I believe that, too; but I do think prospective customers ought to be warned that they're part of a development process.

There's a second problem: Valdocs comes with the "TPM" operating system. Roger Amidon, systems group manager for Rising Star (which produced the software for the Epson), has told me many times that (1) TPM is better than CP/M, and (2) for all practical purposes you use TPM exactly the same as CP/M.

The first statement may be true, but I cannot agree with the second. As an example, TPM doesn't have the CP/M STAT program to allow you to set the output port as TTY:, nor does "ZPIP" allow PIP FILENAME = TTY: (or vice versa) for file transfer. I'm told that TPM has a highly efficient batch processing system that's much more useful than CP/M's SUBMIT, and there are other excellent features—but I'm also told that the TPM user documents will be available Real Soon Now. Thus, fair warning: *if you* buy the Epson Valdocs package, check to see that you're getting all the documents you need, including one on the TPM operating system, or be prepared to work entirely within the Valdocs editor environment *without* ever exiting it.

I had some real problems using Valdocs. Chris Rutkowski told me that was because I was too sophisticated; this is intended for rank beginners. [**Editor's Note:** See the correspondence between Rutkowski and Pournelle on page 442.] Fine. As an experiment, I put the QX-10 and Valdocs documents on John Carr's desk and hid his Selectric. John is an associate editor on science-fiction anthologies; he doesn't normally use computers.

At first John liked it a lot, and he

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certainly was able to use it right off the bat without reading a lot of documents. After a while, though, problems showed up.

Item: the QX-10 uses a single Z80 as both CPU (central processing unit, or brain) and as the manager for putting the text onto the memory-mapped screen. That's not inherently impossible, of course; Zeke II, the machine I'm writing this on, does precisely that. However, the Valdocs software just overwhelms the Z80, so that what goes on the screen lags what you type by an appreciable amount. This is very annoying, and you don't really get used to it. John said he hoped he'd never have to type a long document with that.

Second, Valdocs doesn't have any way to print except to store it first. That means that it takes a minimum of two minutes to address an envelope. The Valdocs documents describe a "screen dump" feature that will print whatever you see on the screen. When we tried that with an address, however, it locked up the machine so that we had to reset it to get out; double plus ungood.

Third, Valdocs doesn't know how to print one sheet at a time. It's apparently fine for continuous fanfold, but if you want to use letterhead, you've got a problem. The program won't accept variable top and bottom margins: you have to set the bottom margin for the whole document, and of course the proper margin for the first page of letterhead is not the same as for the second and following sheets.

Finally, it's just plain slow all around. Example: I wanted to create 64 Valdocs files to check whether the directory could handle more; I created a three-line test file and started in. Save. Restore. Save. Restore. I was watching *The Pajama Game*, but the movie ran out before I was done: 2 hours and 20 minutes.

Getting from the beginning to the end of a six-page document takes 15 seconds. Deleting the first three pages of the same document takes 30 seconds. Killing unwanted files takes nearly a minute each.

In my judgment, the Valdocs system is noble in objective, but I don't think they'll ever get it to work reliably at an acceptable speed on a Z80. If Valdocs were available for something like the Eagle 1600, with its hard disk and 16-bit processor, it might be a different story.

There's also some confusion on the philosophy of Valdocs. On the one hand, Epson tried to make everything similar to what you'd experience if you were using a typewriter. Alas, then it put in a number of undocumented features, some excellent, but none of which you can reason your way to. Then, finally, Epson added other (definitely useful) features that assume you have read and absorbed all the documents and are reasonably familiar with computers. A lot of this looks as if it were designed by a committee that doesn't meet very often.

Valdocs is evolving. Some of the problems may be fixed by the time you read this. I hope so; but I have

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to review what I have, not what I'm told is coming.

Alas, too, I think Epson is up against a fundamental limit. Apple's Lisa software pushes the Motorola 68000 chip right up to its limits, which is why Lisa is so slow. In my judgment, Valdocs has pushed the Zilog Z80 chip *past* its limits; I'd love to be proved wrong, but I don't think Valdocs will ever run properly until something like the 8086 or 68000 is used.

The Epson FX-80 Printer

The FX-80 is Epson's newest top-of-the-line dot-matrix printer. It has very good print quality. With proper software to drive it in the "letter-quality" mode, it would certainly be adequate to produce submission-quality manuscripts and correspondence.

This is a really nifty printer; we had it working with the QX-10 a couple of weeks ago, using it to print graphs we made with the Valdocs graph-construction program. (The graph program is very similar to the CHARTON graph program that comes with the Otrona.) The FX-80 made neat graphs of all kinds: pie, bar, wavy lines, and scattergram.

There's one feature that's also a problem. The feature is "last form access," meaning that the FX-80 is designed to let you remove the last page printed without wasting a sheet. The problem is that the design that allows this makes it very difficult to get the paper into the machine; in fact, I couldn't do it until a nice young lady at the Epson booth at CCS showed me how. (The secret is to ignore the instructions in the FX-80 manual.) Once you get the fanfold paper in, the printer works fine.

The FX-80 is not well designed for feeding in a sheet at a time. With proper text-editor software you could use letterhead paper, but as Valdocs is written at present, that's very difficult.

In fact, we had so much difficulty with paper feed that we finally hooked up the MPI Model 99G printer to the QX-10. John Matlock of The Printer People sent me a cable to allow that; he's interested in a speed comparison between the 99G and the FX-80. I haven't done that test yet, but the 99G certainly prints both letters and graphs with quality at least equal to the FX-80. It also has a normal external tractor that lets you feed in the paper without problems, and it works just fine. Full comparison another time.

Comparing Editors

One of the panels at the West Coast Computer Faire was devoted to text editors and word processing. I'd intended to go to it, but I got trapped in something conflicting. It was conducted by Arthur Naiman. I met him for about one minute before his panel. I'm sorry I missed the panel, because I'm told it was very good. I believe that, because last week I got a copy of Arthur Naiman's new book, *Word Processing Buyer's Guide*, and that's *excellent*.

I would be proud to have written

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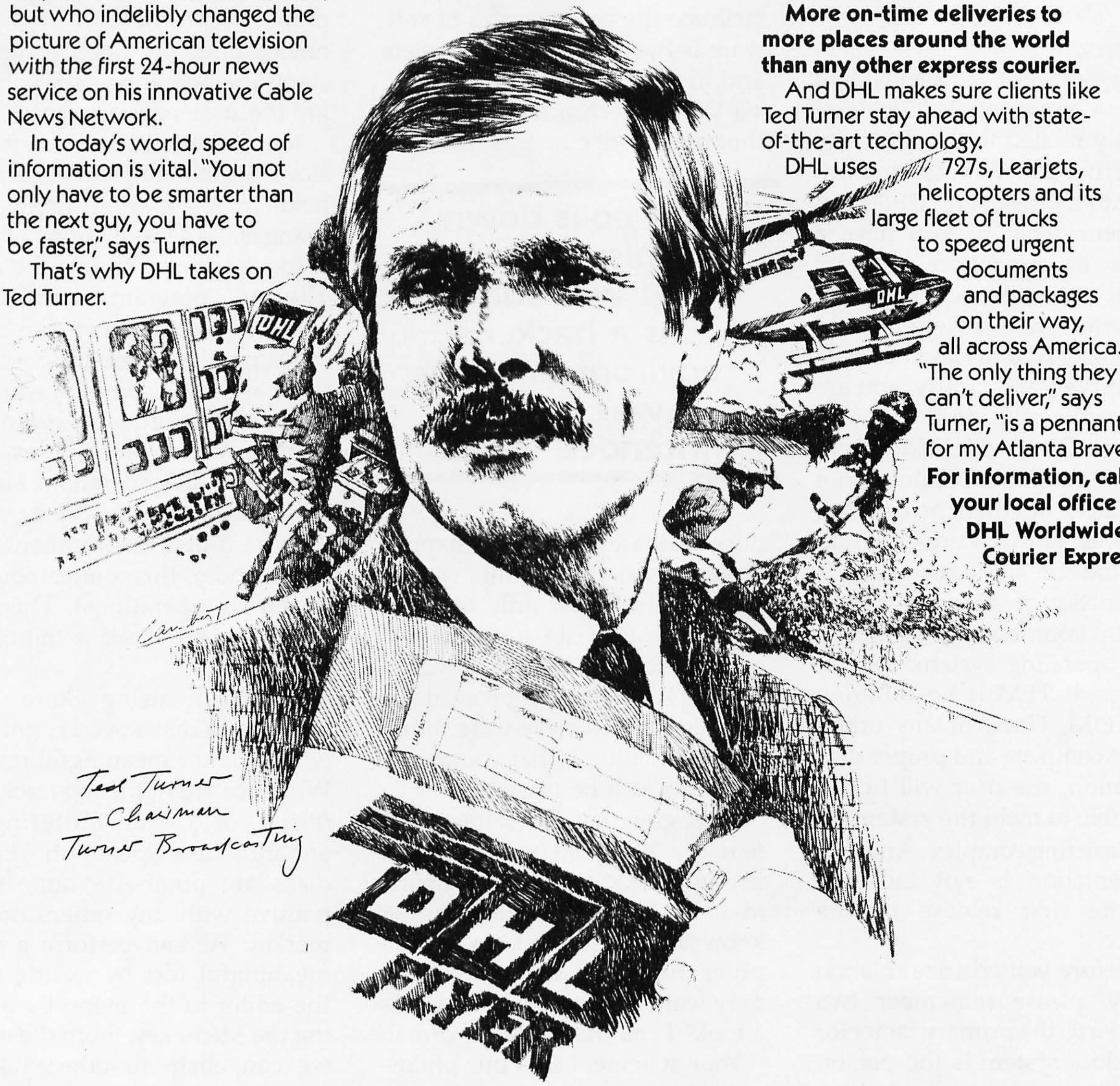

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Epilogue: A Look at Valdocs

As you know if you read Jerry's column, our intrepid user had some problems with Valdocs. Searching for an explanation, he called Chris Rutkowski, president of Rising Star Industries, with his comments and sent Rutkowski a draft version of this month's User's Column. What follows is the exchange that ensued between Rutkowski and Pournelle.

Dear Jerry,

Upon reflection, it seems that your criticisms of Valdocs are primarily related to the difficulty of adapting the Valdocs environment into a preexisting CP/M environment. That is, you have a number of computers, a large body of software, and far more peripherals than anyone would call average. Add to this your data and text files, and clearly, you are pretty well established.

Taking a QX-10 with Valdocs and integrating it into all of this is not a trivial task. But then, no one ever said it was, or that Valdocs would make that job any easier. This is not a function of Valdocs, which is a user environment; it is a function of the operating system, and in this regard, TPM is no different from CP/M, Unix, or any other. Without complete and proper documentation, the user will find it impossible to meld the system into a preexisting complex. And this documentation is not included with the first release of the machine.

But before you criticize this too strongly, please remember two things. First, the primary target for the Valdocs system is the person who will use it as a stand-alone system. For this user, the problems you encountered are of no consequence, for now at least. Second, we are taking action to ensure that the documentation required to fully integrate the QX-10/Valdocs system with other environments is provided. This includes

- a TPM primer, which is being written by the author of a popular CP/M primer
- a plug-in 8-inch and 5¼-inch disk-controller card that will facilitate the easy transfer of software between the Valdocs system and any CP/M system
- a Valdocs technical manual that thoroughly documents the Valdocs database filer, the bit-mapped screen drivers, etc. (This section will be of interest only to those who wish to write software specifically for the Valdocs environment.) These should be available by August. Thus even the inherently difficult job that you are attempting will be feasible.

"It boils down to this: Valdocs is not well suited as a hacker's environment, nor was it ever intended to be."

I disagree that the Valdocs system was "designed by geniuses for use by idiots," unless you define idiot as "someone who neither knows nor cares about how a computer functions internally—who only wants to use the machine as a tool." I call that person normal.

Your statement that our philosophy is confused is both inaccurate and inappropriate. As long as the user remains in the Valdocs environment, things are simple and straightforward, although capable of quite sophisticated and comprehensive interactions. But as soon as the user departs that environment, he's on his own, just as he's on his own using any other operating system/computer combination. The current expert-level settings are arranged so that at the novice levels, even the possibility of departing the Valdocs environment is precluded. *Thus* the novice does not need to understand the operating system to enjoy the user environment.

Your observations about the slowness of the Epson disks is the result of comparing apples and oranges. A Store from within Valdocs is not a simple file save. The Indx program, which is invoked by Store, is a complex cross-indexing database filing system that has little in common with that of any other word processor on the market. When Store is invoked, numerous disk operations have to take place to update the database (in a hard-disk environment with a large index, this could amount to dozens of operations). This can, quite logically, take a minute or more.

Obviously, using Store as a measure of disk speed is not likely to produce meaningful results. While we are not using track buffering or cache buffering to enhance disk speed, the Epson disks are otherwise quite competitive with any others on the market. We can perform a more meaningful test by exiting from the editor to the menu by pressing the Menu key. From the menu we can chain to other Valdocs modules without having to close any temporary files or the like. When chaining from the menu to other modules, the length of time

from the keypress to the blanking of the screen is the length of time it took the system to load the program off disk and start execution. Press one of the other function keys, such as MAIL, SCHD, or DRAW. The results are interesting: Schd, which is about 52K bytes in length, takes about 13 seconds to load. Mail, at 37K bytes, takes less than 10 seconds. Frankly, while no hard disks need feel threatened, these times are quite respectable and are typical of what a user would expect to experience with any CP/M-like system using 5¼-inch drives.

As you observed, the Store mechanism is too slow to be useful for a Save. As a result, we created a separate mechanism to execute Saves. This mechanism has been in every version of Valdocs you have ever seen. (Note that when you press CONTROL Q, a new menu appears in the editor. This menu allows normal CP/M such as Saves, Retrieves, Directories, etc. However, we felt that such operating system operations were inappropriate for an elegant Save mechanism.) The actual Save mechanism is documented on page 2–24 or 2–25 of the Valdocs manual. In short, with only two keystrokes, you can save any file. The length of time to execute this save is only 15 seconds or so for files of any length.

While chaining from the editor to any other function, all editor work files are closed (which is the mechanism of a Save). This assures the user that his work is safe and also provides some unique capabilities. For example, at the end of a workday the user can chain out to menu and then power down. When he reboots the system in the morning, he'll find that Valdocs will sign on with his file in place, all tabs and margins correctly set, and his cursor exactly where he left it in the document. Additionally, this ensures that simply using the various functions of Valdocs continually saves the user's work. Thus the need to knowingly perform a discrete Save operation is dramatically reduced.

This Save mechanism is not intuitive, but, then, the necessity to do Saves at all is in no way intuitive. So, the need to save your work and the procedure for doing it can easily be taught in the same place at the same time. (In developing Valdocs and HASCI, we have found that there are perhaps a half-dozen things that a prospective user must learn.) By August, Save will have been reduced to a single keystroke.

"The current (May 1983) version of Valdocs is only a starting point. Much remains to be done to add in every possible feature."

Our reasons for using TPM are many and valid. TPM has a Chain function, without which Valdocs would have been nearly impossible. It also supports a multibank system as well as up to 255 user areas and allows cross-user operations (vastly superior to CP/M's user constructs). By August, TPM will have hashed directories and numerous other improvements. Our reason for choosing TPM was that in 1982, TPM already supported many of the features now being introduced in version 3.0 of CP/M. TPM is compatible with both 1.4 and 2.2 versions of CP/M, but that doesn't mean that their user interfaces are identical. (Most common commands—DIR, ERA, PIP, SAVE, REM, etc.—however, can be used identically, even though they possess numerous enhancements.) It means that they are functionally equivalent. The goal of Computer Design Labs (authors of TPM) was, of course, to have any CP/M-compatible software execute properly within the TPM environment. This has been no easy task.

CP/M was written in 8080 code, and more than one developer using CP/M on a Z80 took advantage of this to do some very strange things with the additional Z80 registers. Furthermore, more than one aspect of CP/M is documented quite poorly, complicating the task. As of this writing, we know of no CP/M program that does not run correctly under TPM. If any are found, the folks at CDL will be delighted to remedy the situation.

Your difficulties are in fact a function of your highly developed computer literacy: through the traditional school of hard knocks you've learned a lot of painful lessons about the need for documentation, the dangers of systems, and so on, lessons that simply don't apply in the Valdocs environment. It boils down to this: Valdocs is not well suited as a hacker's environment, nor was it ever intended to be. However, your statement that Valdocs is not suitable for professional writing tasks is in disagreement with the findings of our other 30 or so test sites, which include a great many professional wordsmiths.

The current (May 1983) version

of Valdocs is only a starting point. Much remains to be done to add in every possible feature. But our stated goal is that "90 percent of the potential users of Valdocs will never need any software not provided directly by the Valdocs environment." It is a tall order—and one which we expect to have largely accomplished within a year. In the meantime, most users will find Valdocs very satisfactory for most applications. Users who have very specific requirements in mind are, as always, well advised to check carefully before assuming that Valdocs will or will not suit their purposes.
Chris Rutkowski

Dear Chris,

I really think you have misunderstood, and perhaps my readers may, so I'll try to be more clear.

Agreed: integrating the QX-10 into my system here was what I first had in mind. I'd still like to try it *as a small computer* using one or another text editor. However, I do not know what terminal it emulates, and I still have no CP/M for it. TPM may be excellent, but I would have to write an assembly-language program to transfer files, as far as I can see. The package I got with the last software delivery said "Your QX-10 package may not be complete. The following items may be on backorder: CP/M Diskette, CP/M+ Manual."

In any event, I put the system in the other room and put the Selectric away. I paid John Carr's time to have him learn the system and handed him the manuals. John, an associate editor on science fiction anthologies, is totally unfamiliar with CP/M or any other operating system. His computer experience in the past has been confined to using a text editor after someone loaded the editor for him. Thus this seemed a fair test.

When the system crashed (after the directory was full) completely without warning, it didn't make John feel better about the QX-10. I should, I suppose, have shown him how to cancel files (or he should have done it, from reading the manual). Most of the files in the system were nothing more than addresses. That's one of the most serious problems: WE COULD NOT MAKE IT PRINT WITHOUT SAVING THE FILE FIRST.

We tried the Screen Dump instructions, and they don't save the file. What are we supposed to do? Save the address for the envelope, using Store—which takes a fairly long time—then cancel that file, which takes more time? True, we often use window envelopes, but one of the major difficulties we had was with the print system using letterhead and single sheets of paper. I'm trying it now, with the disk that came with the documents, presumably what is for sale to the public. We'll see what happens.

"As I understand it, until you Store the document, you are writing over your last Save. That's not what I would call safety."

Incidentally, now I'll try the setup program and set the clock and such.

I changed the printer to FX-80. It was already set to the expert level. I fear I can make no sense of the input command; if there's a way to set things to TTY:, I cannot find out how that is done. Otherwise, as instructions dictated, I did not change anything. The clock, incidentally, is very accurate and has been running on time within a minute since the machine arrived.

Now for your points. I will wait for the TPM Primer. My remarks are pretty well confined to the experience within the Valdocs system, and we'll look at the Epson as a small computer independent of that when we have either of the TPM documents (I have one set, but they didn't explain how to transfer files. Unfortunately, the Osborne is not here just now; it reads a lot of formats, and I could transfer files from it to the Epson, etc., but that just doesn't seem reasonable).

I anxiously await the new controller that allows reading and formatting (I presume it will either offer a variety of disk formats or will write to previously formatted disks in the format they are in. *I expect* that it can read from one format and write to another, as the Lobo does).

I'd love a look at the Valdocs technical manual, but I don't really need it for what I'm trying to do now.

I still want Valdocs to work very much. I would like to have the whole system, with the database and address book and all the other features. However, until we can easily and conveniently write letters and do the general work of the office here, the other features aren't relevant.

It is certainly a drawback not to be able to change bottom and top page margins within a document. I don't think I can do that. I will try again. . . .No. When I change the bottom margin, wherever I am, I find myself at the top of the page again. This means that the system is nearly useless for letters on letterhead and not very good for other documents because you must format your text all at once. I have just tried the Size key, but I don't think it does anything.

More thoughts. For those used to computers, the type "drags" across the screen and cursor motion is very slow. I agree that's a function of what you're used to, and I am, on purpose, accustomed to the fastest and best word processing system.

Incidentally, the hyphen feature of Valdocs is a fatal error. Valdocs

broke my line at the hyphen in word-processing. I had not intended the word to be broken there. Most authors do not want the machine to decide things like that for them, and I always send my manuscripts with no hyphens at all unless I intended them. I never leave a hyphen at the end of a line because that would be ambiguous to a typesetter or copy editor.

I will now try to Save using the instructions in the manual. I used Copy Disk, waited for a new prompt, and then pressed UNDO. Saving these three pages took 21.19 seconds, which I agree is reasonable. But it is also counterintuitive and differs from the philosophy we have up to now been led to expect. Moreover, I do not believe this makes a backup copy. As I understand it, until you Store the document, you are writing over your last Save. That's not what I would call safety. I am probably a fanatic on the subject of document integrity, but I am not likely to change, and neither are most authors.

I'm willing to believe you about TPM, but the fact is that I have been unable to make TPM do what CP/M's Stat program does. I have also been unable to figure out how to do the equivalent with whatever programs TPM employs. It may be a wonderful operating system, optimized and all that, but I don't have what it takes to learn it.

I would make the following improvements in Valdocs:

1. Have a Kill program that lets you run down a list of files and mark each D for Delete; then when you execute the program, it gets rid of them.
2. Make it possible to print without Storing the file. Sometimes we only want a short letter; we have no intention of keeping a copy, and we're interested in getting the work out the door. Same for addressing envelopes; we have to keep a typewriter around to make mailing labels and envelopes.
3. Allow imbedded format commands of some kind so that, for example, we could change the bottom margin on page 2.
4. Have a Setup file that you can put your favorite defaults into. Tabs, for example; why must I set them for each document?
5. Naturally, you must have a way to deal with John's data disk disaster. Was that an older copy, or does it happen on all? I may test this tonight. Try to overfill the directory, and overfill the disk, and see what happens with the distribution software. First we will test the system to see how well we can print letters. I have fooled the FX-80 into believing there is paper by inserting a second sheet behind the first, but that's a pretty lousy way to have to proceed.
6. I'd think, then, that mating the system with the printer would be useful. There should also be an Install program that would let you use Valdocs with the RS-232C port so that it could be used with Diablo and NEC Spinwriter printers, although I agree that these new Epson printers produce high-quality work.
7. The Shift down-arrow doesn't really move to next visible page, but up a few lines. Perhaps you need a Multiplier key, as in EMACS, MINCE, and Wordmaster; in those ^W multiplies the next command by a factor of 4. Multiple uses multiply in cascade.

"I agree that users don't need to know everything that's going on in the system, but they should be able to do things quickly and easily."

As to "designed by geniuses for execution by idiots," I agree that users don't need to know everything that's going on in the system, but they should be able to do things quickly and easily.

Anyway, there's a lot to like about Valdocs, and it could be terrific if implemented on a faster machine with a hard disk. Also, when finished for the Epson, I agree that it could be about as good as any system I know of, especially for the price.

I have to quit now. We'll see how the printing goes. [**Editor's note**: At this point in the letter, the sentences are printed diagonally across the page. After some investigation, Jerry discovered that if you insert the paper into the printer crookedly and then try to fix it, the printer begins printing. The reason for this is that the software sensor that determines whether the paper is indeed in the printer can be tripped before paper is located correctly under the print head. Jerry's letter continues now after several lines that illustrate the problem better than this description. . . . **P. C.**]

If you do not tell the printer to stop between pages, it does a formfeed when it starts, though you didn't tell it to, so don't try that with a single sheet in the machine.

The slowness of this screen is about to drive me crazy. I can type about four words ahead of the screen, sometimes, and sometimes not; it's not obvious what the relationship is. But I could live with all that. What I can't live with is the inability to write letters.

It is now 11:00, and I began this at 8:50. That's a lot of time for a 6-page letter. It took one minute and two seconds to Store. We'll do that again, and retrieve it. I have been an hour and a half writing this. I would have done far better with a Selectric. Sigh.

Jerry Pournelle■

Text continued from page 440:

this book. It's clear, objective, and damned thorough. It even has a review of WRITE, the text editor I use; Naiman read one of my articles and managed to get hold of Tony Pietsch, WRITE's author, and buy not only WRITE, but a computer modeled after Ezekial.

I gather from Naiman's book that, like me, he has just about every word-processing and text-editing program in existence. He even wrote the Sybex *Introduction to Word Star*. (Interestingly, Naiman used WRITE to write it.)

Naiman uses an interesting point system to evaluate word-processing programs; thus you can see *exactly* why he rates the various programs the way he does. This book discusses just about every text editor I know of, plus a lot I had never heard of before reading his book. Anyone contemplating the purchase of a text editor or word processor should run, not walk, to the store and get this book before spending a single dime on word-processing software.

The Z-29

When the new Zenith Z-29 keyboard arrived, I was about to go off to Bellingham; I wouldn't be able to do anything with it for at least a week. As it happens, the night before the Z-29 arrived Chuck McMannis' home terminal had died. Chuck is our new research assistant. The solution, therefore, was obvious, and Chuck took the Z-29 home with him.

When I came back I found he had made his other boss (the one who pays him a living wage) buy a Z-29 for their minicomputer. Chuck thinks the Z-29 is the best thing he's seen for the money. The following is largely drawn from his report.

The Z-29 (H-29 in kit form) is a second-generation machine. It fixes most of the identified bugs that existed in the Z-19 and adds a detachable keyboard as well. Not only that, it has been sculpted to make it more like a Selectric. It has excellent feel. Some find it a bit "thick" for sitting on a desk although perfect for putting on your lap; I haven't noticed any problems at all.

If your system can use a Z-19, you can plug in the Z-29 and run. In addition, the Z-29 can emulate a Hazeltine 1500 and a Lear Siegler ADM 3A. Best of all, from Tony Pietsch's viewpoint, it has a full ANSI (American National Standards Institute) mode. This is important because all the big computer companies are moving toward the ANSi Standard communications mode.

I'm not entirely happy with the key layout. The arrow keys are put over for right-hand use; they're grouped above the Return key. I'd prefer a small separate left-hand pad of arrows with Home in the middle. This is a matter of taste and what one is used to, of course, and it won't take long to get used to the Z-29 layout.

The character set is aesthetically pleasing. There are several new attributes: underline, blink, and half-intensity. The screen is 24 by 80 with a twenty-fifth status line. The twenty-fifth line accesses a built-in real-time clock. An alternate character set is included.

It does have problems. They work hell out of the 8051 chip in there, and

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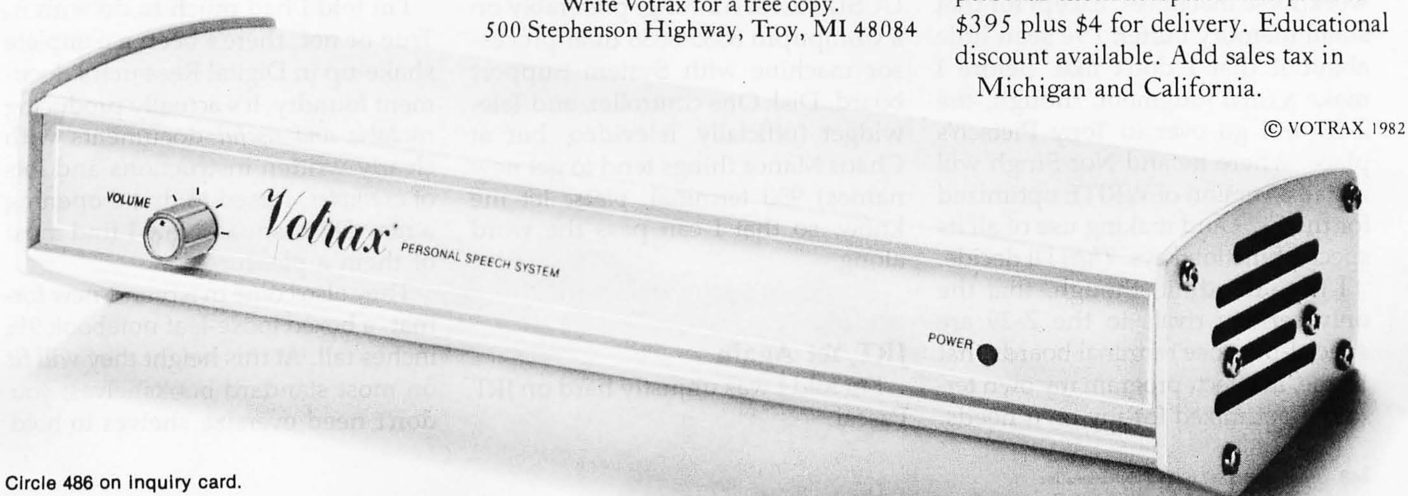

Circle 486 on inquiry card.

Zenith didn't supply enough memory: the buffer is only 32 characters long, and that can be overrun. I'd have thought with memory so cheap the company would have provided at least 128 characters; 256 would have been better. It did provide an X-ON X-OFF handshake routine (a way to tell the computer "Stop sending! My buffer is full!"), but I hope that one day there'll be an upgrade to add more memory.

For reasons I do not understand, the cable connecting the keyboard plugs in at the *back* of the terminal. Nearly every terminal does this; I can't think why.

The brightness control is a knob on the back of the terminal, neatly placed so that you cannot adjust screen brightness while sitting where you'll look at the screen. Obviously Zenith ought to have made this a software adjust (as with the Otrona).

Note: Steve Ingish of Zenith tells me putting the connection and control on the back saves about $50 on the terminal's price.

On the plus side, Zenith has provided a software setup menu; no longer must you flip physical switches, then turn the terminal off and back on to change the terminal parameters. Another plus that Ciarcia will like: there's almost no EMI (electromagnetic interference).

Chuck McMannis' final comment is, "If you can find a better terminal, buy it." He has seen nothing he likes better at anywhere near the price.

I tend to be a little more cautious; I want to experiment with the Z-29 for a while. Even so, there's a very good chance that the Z-29 will become the principal terminal for our workhorse machines. Except for that small memory buffer, I've seen little about it that I don't like. Before I make a final judgment, though, the Z-29 will go over to Tony Pietsch's place, where he and Nor Singh will install a version of WRITE optimized for the Z-29 and making use of all its special-function keys. *Then* I'll decide.

I have to admit, though, that the only serious rivals to the Z-29 are special-purpose terminal boards that let me, in effect, program my own terminal optimized for my own needs. I have a couple of those, and I'll report on them in another column. Meanwhile, I like the Z-29 quite a lot.

Oh, It's Easy To Get It Running . . .

In Ithaca I was taken to task by a professor of computer science. I have, it seems, been unkind to Pascal and have confused the language itself with particular implementations. I pointed out that I can only evaluate implementations; this is the User's Column, and I don't generally write about stuff my readers can't use.

He agreed, but then told me with some vigor that there exists a public-domain UCSD Pascal that can be made to run on most CP/M S-100 bus systems. He also informed me that it's a wonderful implementation, complete with easy methods for opening and closing both sequential and random-access files under CP/M; features I very much want.

"Wow," I said. "How can I get this running?"

"Well, it's easy. If I had access to your system and your CBIOS (customized basic input/output system), I could have it running in no more than a day," he replied.

I quickly lost interest. Alas, I can't afford to have him come to Hollywood and install this marvel, nor, I fear, is that practical for many of my readers. I do recall that MacLean had an earlier version of UCSD Pascal running and had real problems with the built-in editor. It was also very slow. This caused him to learn PL/I, and he didn't live to return to Pascal.

If anyone has a simple and foolproof way to get public-domain UCSD Pascal running, preferably on a Compupro 8085/8088 dual-processor machine with System Support board, Disk One controller, and Telewidget (officially Televideo, but at Chaos Manor things tend to get new names) 950 terminal, *please* let me know, so that I can pass the word along.

JRT Yet Again

I'm told I was unjustly hard on JRT Pascal.

I said nothing I care to retract, but perhaps the tone was unduly harsh; let me clarify. JRT Pascal certainly works in the sense that you can write useful programs in it. I like Mr. Tyson's price and attitude. His Version 3.0 has fixed a number of bugs and glitches that made earlier reviewers so unhappy.

For all that, JRT Pascal is not, in my judgment, a good teaching instrument because it is so thoroughly nonstandard. The error messages are not the same as standard Pascal, and the extensions are done quite differently from the way anyone else does them. Programs written in JRT Pascal are almost guaranteed not to compile with *any* other Pascal compiler; worse, a number of standard programs out of such books as Osborne's *Practical Pascal Programs* won't compile on JRT either.

JRT Pascal error handling is not only nonstandard, but also unduly frightening to the beginning user; and the compiler never recovers from any error, so that JRT Pascal won't catch more than one error per compilation. For those who are as confused (or careless) about semicolons as I am, this can be very time consuming.

In other words, what it mostly has going for it is the price. You can write practical programs in JRT Pascal; if you're not interested in transporting those programs to some other machine, JRT is a bargain. To quote one programmer friend, though, I'd really hate having to write large programs in it.

Revolution at Digital Research

I'm told I had much to do with it. True or not, there's been a complete shake-up in Digital Research's document foundry. It's actually producing *readable and useful* documents with clearly written instructions and lots of *examples*. I used to dread opening a new DR manual. Now I find most of them a pleasure.

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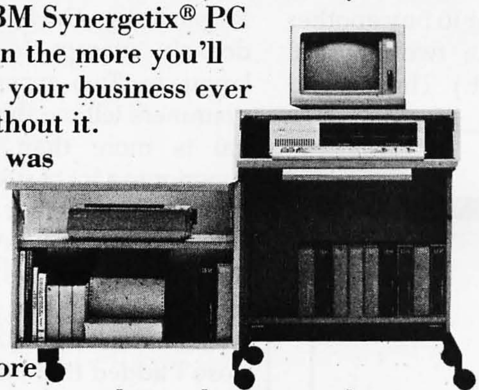

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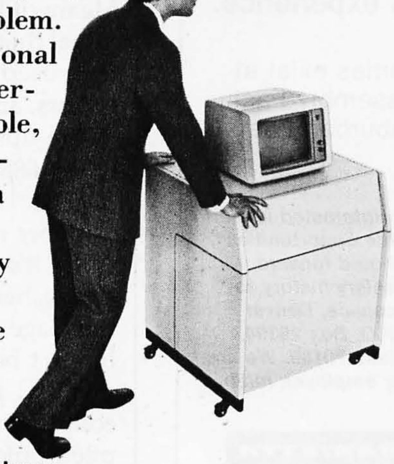

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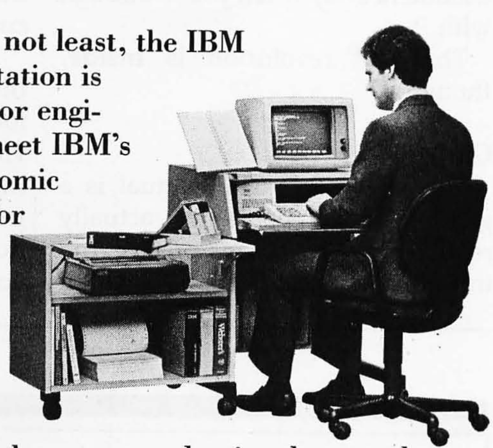

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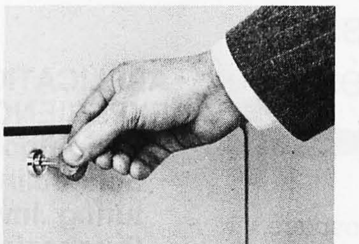

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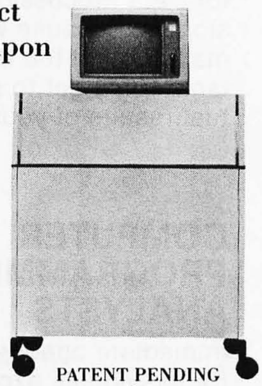

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your computer documents. The slipcase at first seems an affectation, but it isn't: the box serves as a placeholder to show where to put the document away when you're through with it.

The real revolution is inside, though.

CP/M-68K

The new CP/M-68K manual is a good case in point—it's actually readable! There's a sane preface, the introductory material is written in plain English, there are plenty of examples, and there's considerable sympathy for beginners. The organization is nice, with an overview, then details, and, once again, *lots of examples*.

This clarity continues throughout the first volume (*User's Guide*) of the four-volume manual set. (All four volumes are bound into one looseleaf notebook, which is a mistake; most users will prefer to buy another notebook and make two physical volumes of the set.) The second volume, *System Guide*, and the third, *Programmer's Guide*, are not so clear, although both are *enormously* improved over previous DR CP/M documentation. I can't in conscience pronounce them excellent, but they are darned good, and such a great improvement over what we normally expect from DR that there's no comparison.

The fourth volume, *The C Language Programming Guide for CP/M-68K*, doesn't attempt to teach the C language. Two experienced C programmers tell me the CP/M C manual is more than adequate and superior to a lot of system documents they've encountered; one added, "Of course that's not saying much." It does have examples, and I haven't found anything that sent me up the wall. I haven't read it all, either. I suppose I added that last sentence, not to be catty, because of my previous experiences with Digital Research documents. That's probably unfair; the new documents are so darned good I ought, I suppose, to expect clarity and good examples rather than terseness and obscurity.

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MARTIN MARIETTA

CP/M-68K and the Sage

When the CP/M-68K for the Sage first arrived, I'd expected the Compupro 68000 board for the S-100 bus experimental machine to come within a couple of days. Thus I waited for it so we could compare the systems. Alas, Dr. Godbout discovered a problem with his 68000 board and ceased shipping them until it could be fixed. Meanwhile, the Telewidget 925 terminal that operates the Sage was being used for installation of text editors, and I've only just got it back.

The upshot is that I've barely got CP/M-68K up and running on the Sage II.

It *does* run, and if you're used to CP/M it's easy to use. We haven't yet established communications between the Sage and other machines, so I haven't been able to ship over very many C programs. I did type in a couple of simple ones, and they compiled quickly and easily.

We've been running the Sage since last summer. It has been shipped to San Diego a couple of times for one

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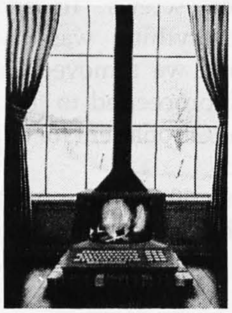

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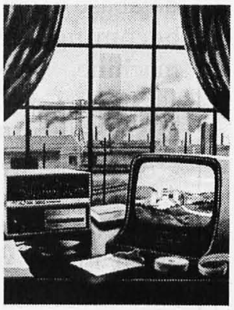

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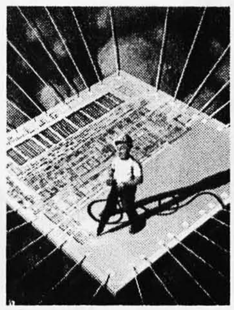

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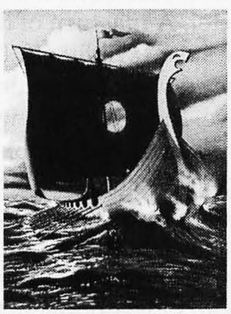

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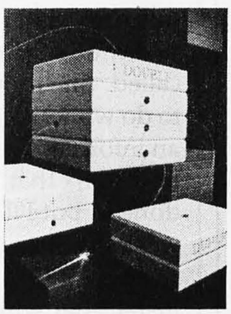

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of Alex's mad friends to experiment with. Because it's the only machine I have that runs Modula-2, it got a good workout while I was learning that language.

We've yet to have a glitch. About a dozen readers tell me they bought Sage machines largely on my recommendation, and none of them are unhappy. Now that we have CP/M for the Sage, I expect to use it even more. Incidentally, I'm beginning to see software written for the Sage. A database came in today. The Sage is becoming an important little machine.

Disassembling Adelle

Adelle is my early-model Otrona Attache. She goes with me on all my travels. Recently she developed a glitch in her disk systems. It happened on a Thursday afternoon; the following Saturday at dawn Larry Niven and I were scheduled to catch a plane for Bellingham, Washington, where we've laid a principal scene of our next novel.

In panic I called Fred Whitney of CTI Data Systems. CTI is the West Coast representative for Otrona. Fred listened to my tale of woe.

"We could swap out your disk drives," he said. "But I couldn't get it done before Monday because I don't have a set of drives here."

My panic must have been evident because he told me to hang on. A few minutes later Judy Seelig, Mr. Whitney's programming expert, called. She thought my problem had to do with disk drive speeds. "There's an information sheet from Otrona on how to fix that," she said. "I've never done it, but I'll come out and we can work on it together. There's a new software ROM update, and we can install that while we're at it. To save time, please take the machine apart before I get there."

With some misgivings I spread a thick layer of newspapers across my desk and took Adelle out of her case. She came apart quite easily; it takes only one tool, a Phillips screwdriver. I began to remove parts: the circuit board, the screen, the power supply, the disk drives. It wasn't long before my pretty little machine was a pile of parts and small screws, and I was getting a little worried. "It'll be all right," I told Chuck McMannis. "She told me to take it apart, so she'll know how to get her together . . ."

There was only one problem. Judy Seelig had *never* seen a machine taken quite so thoroughly apart, and she hadn't brought any documents on how to reassemble Adelle.

"Relentless application of logic," I muttered. We installed the new ROM, and I began to put parts on and tighten screws. In about 10 minutes everything was back together. Then we removed the disk drives and proceeded to follow the instructions Otrona sent for adjusting disk speed.

In another 10 minutes Adelle was back together and working as well as ever she has. That's one well-designed little machine. I don't recommend that you casually take yours apart, but I can testify that, provided you're intelligent about reassembly, it doesn't seem to hurt the machine.

Incidentally, I discover there's a whole series of built-in diagnostic tests for the Otrona. They're described in the *Technical Manual*, a document normally supplied to dealers, but which users can purchase.

I'm not too happy about those disk drives. They do indeed have a speed control. It's a screwdriver-adjusted potentiometer. A *tiny* turn of that pot will put the speed wildly off. I'd have thought they'd want something a lot less sensitive. Indeed, while we were in Bellingham a speed problem developed again, forcing me to remove Adelle's case and adjust her "B" drive. It was easily fixed, but I hope I won't have to endure that every trip.

Adelle is an older-model machine. The new ones have somewhat different disk drives. Fred Whitney tells me they've never seen any problems with the new ones.

Things My Postman Brings Me . . .

John Lawler of Ann Arbor, Michigan, writes in praise of VEDIT, particularly used with the TVI 950 terminal. He's been using VEDIT for

The Micromint Collection

Micromint. Supporting the varied projects that appear in Steve Ciarcia's monthly article in BYTE magazine, "Ciarcia's Circuit Cellar." Offering a wide range of computers and peripherals supporting the needs of the hobbyist as well as worldwide corporate clients.

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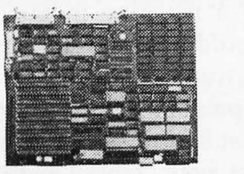

The MPX-16 is Steve Ciarcia's most ambitious project to date. The computer runs all application software written for the IBM PC and is IBM PC bus compatible. Can be used with video monitor & IBM keyboard with optional adapter.

Buy the MPX-16 in the form that best meets your budget. As a bare board, as a wave-soldered board that contains all components less the IC's, as an assembled and tested circuit board or as a complete system.

As featured on the cover of "BYTE" magazine. Also featured in "Ciarcia's Circuit Cellar" November, December 1982 & January 1983.

- Runs all application programs written for the IBM PC (simply boot up the system and slip in a disk formatted for the IBM PC).
- IBM PC bus compatible + 9 expansion slots.
- Intel 8088 16-bit microprocessor.
- Optional Intel 8087 math coprocessor.
- 256K bytes on-board memory.
- Up to one megabyte of system memory.
- Up to 64K bytes of system ROM/EPROM.
- Two RS-232C serial I/O ports.
- Three parallel I/O ports.
- Disk controller for 5¼" or 8" drives.
- Sixteen levels of vectored interrupts.

MPX-16 Microcomputer circuit board assembled w/64K RAM, CP/M-86 or MS-DOS ..... $1,895.
MPX-16 as above with 256K RAM .... 2,135.
MPX-16 Semi-Kit (wave soldered circuit board w/all components) less IC's .... 595.
Complete kit of IC's w/256K RAM .... 595.
MPX-16 Unpopulated (bare) pc board .... 300.
CP/M-86 Operating System .... 200.
MS-DOS optionally available
MPX-16 Switching Power Supply including cable harness for 2 disk drives .... 300.
MPX-16 Technical Reference Manual .... 50.
MPX-16 Metal Enclosure with cutouts for two 5¼" full height drives .... 300.
Tandon TM 100-2 double density drive ...... 300.
Televideo Model 910 Serial Terminal .... 675.
IBM PC Keyboard Interface Adapter .... 100.
Serial terminal cable .... 35.
Parallel printer cable .... 35.

Shipping and handling additional on MPX-16 orders.

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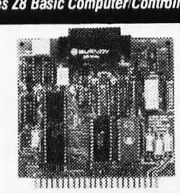

As featured in Ciarcia's Circuit Cellar, BYTE magazine, July & August 1981.

- Uses Zilog Z8671 single chip microcomputer.
- On board tiny BASIC interpreter.
- 2 parallel ports plus serial I/O port.
- Just connect a CRT terminal and write control programs in BASIC.
- 2K bytes of RAM, up to 4K bytes of ROM.
- Baud rates 110-9600 BPS.
- Data and address buses available for 124K memory and I/O expansion.
- Consumes only 1.5 watts at +5, +12 & −12.
- Cross Assemblers for various computers.

BCC11 Assembled & Tested .... $149.
New Low Price

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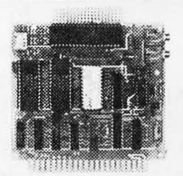
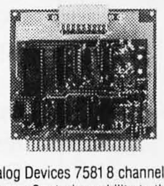
Z8 MEMORY, I/O EXPANSION, CASSETTE INTERFACE



- Add up to 8K of memory plus 3 parallel ports.
- Cassette Interface—300 baud K.C. Standard.

BCC03 w/4K Assembled & Tested .... $140.

Z8 ANALOG TO DIGITAL CONVERTER NEW!!!



- Uses Analog Devices 7581 8 channel 8 bit IC.
- Adds Process Control capability to the Z8.
- 1000 samples per second.

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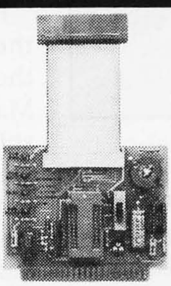
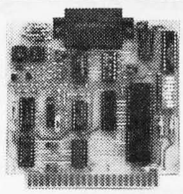
Z8 EPROM PROGRAMMER



- Transfer BASIC or Assembly Language application programs from RAM to 2716 or 2732 EPROM.
- Requires Z8 Expansion Board for operation.

BCC07 Assembled & Tested ....$145.

Z8 SERIAL EXPANSION BOARD



- Adds additional RS 232C and opto-isolated 20 ma current loop serial port to the Z8.
- Runs at 75 to 19,200 baud in all protocols.

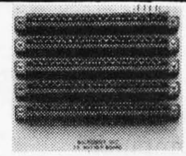
BCC08 Assembled & Tested .... $160.

Z8 16K MEMORY EXPANSION BOARD NEW!!!

- Add 16K of additional memory, RAM or EPROM, to your Z8 System Controller in any multiple.
- Uses 2016, 6116, 2716 or 2732 memory types.

BCC14 w/8K Assembled & Tested .... $120.

Z8 FIVE SLOT MOTHER BOARD



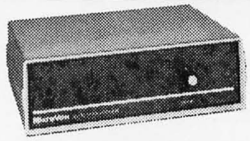
MB02 Assembled & Tested .... $69.

Z8 CROSS ASSEMBLERS

From Allen Ashley
TRS-80 Model I or III .... $75.
CP/M 2.2 8" or Northstar 5¼" .... 150.
From Micro Resources
CP/M 2.2 8" or APPLE 5¼" .... 75.

SPEECH SYNTHESIZERS

MICROVOX TEXT-TO-SPEECH SYNTHESIZER



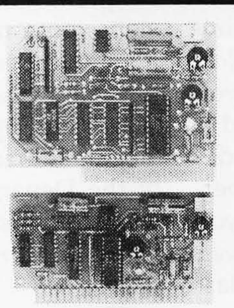
As featured in Ciarcia's Circuit Cellar BYTE Magazine September, October 1982.

Microvox is a second generation professional voice quality text-to-speech synthesizer that is easily interfaced to any computer, modem, RS-232C serial or parallel output device and provides speech of unbelievable clarity.

- Unlimited vocabulary.
- 64 programmable inflection levels.
- 6K text-to-speech algorithm.
- Full ASCII character set recognition and echo.
- RS232C and parallel output.
- 1000 character buffer, 3000 optional.
- Adjustable baud rates (75-9600).
- Spelling output mode.
- 7 octave music and sound effects.
- On board audio amplifier & power supply.
- X-On/X-Off handshaking.

MV01 Assembled with 1K buffer .... $299.
MV02 Complete Kit with 1K buffer .... 219.
Add $15.00 for 3K buffer option.

SWEET-TALKER VOICE SYNTHESIZER



As featured in Ciarcia's Circuit Cellar BYTE Magazine, September 1981

The Sweet-Talker Voice Synthesizer allows you to add speech of unlimited vocabulary to your Apple II or any computer with a parallel printer port at very low cost.

- Utilizes Votrax SC-01A speech synthesizer.
- Unlimited vocabulary.
- Text-to-Speech Algorithm on disk for Apple II.
- Contains 64 phonemes accessed by 6-bit code.
- Four levels of programmable inflection.
- On board audio amplifier & volume control.

ST02 Apple II plug-in, Assembled & Tested with Text-to-Speech Algorithm on 3.3 disk .. 141.
NEW LOW PRICE!!!
ST01 Parallel Port Version, Assembled .... 99.
New Low Price

VOTRAX SC-01A PHONETIC SPEECH SYNTHESIZER

The SC-01A Speech Synthesizer is a completely self-contained solid state device that phonetically synthesizes continuous speech of unlimited vocabulary. Used in Microvox and Sweet-Talker.

SC01A Quantity 1-99 .... $52. ea.
100 + ... 40. ea.
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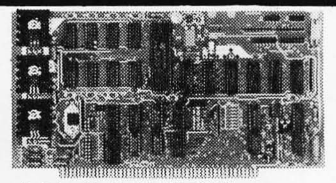
E-Z COLOR GRAPHICS INTERFACE



As featured in Ciarcia's Circuit Cellar BYTE Magazine, August 1982

Add color graphics, animation & 3-D effects to your S-100, TRS-80 Model I and III & Apple II at low cost. The Super Editor software package includes a pattern editor, sprite editor, slide show, and demo scenes all in BASIC. Can be used with Color Monitor or TV set and rf modulator.

- Resolution—256 X 192 Pixels.
- 16 colors including Black & Transparent.
- 16K Bytes on board I/O mapped video memory.
- Advanced TI TMS9918A Color Video Processor.
- 32 SPRITES facilitates 3-D effect.
- Composite Video output.
- Krell & Terrapin have LOGO software packages to support the E-Z Color Boards.

Apple II E-Z Color plug-in board with Super Editor on 3.3 disk.
EZ01 Assembled & Tested .... $150.
EZ02 Complete Kit .... 125.

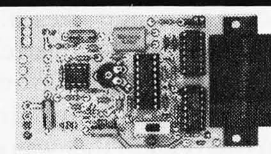
NEW!! S-100 E-Z Color Graphics board with sound generator, Atari type joy stick interface, plus MBasic CP/M Super Editor Software on 8" disk.

EZ04 Assembled & Tested .... $289.

TRS-80 Model I or Model III E-Z Color w/ Super Editor software, power supply and enclosure.

Assembled & Tested .... $249.
Complete Kit .... 219.

300 BAUD ANSWER/ ORIGINATE MODEM KIT NEW!!!



As featured in Ciarcia's Circuit Cellar BYTE Magazine, March 1983

The newest item to Micromint's growing list of products is this 300 Baud Modem. It is crystal controlled, uses the TI TMS 99532 IC, contains just 25 parts and can be used with an acoustic coupler or in a direct connect mode.

MD04 Complete Kit .... $60.
MD05 Transformer for Direct Connect Mode .... 9.
AC01 Acoustic Coupler Kit .... 18.

TRIPLE VOLTAGE POWER SUPPLIES

+5v @ 300 ma. +/− 12v @ 25 ma.
UPS01 Assembled & Tested .... $35.
UPS02 Complete Kit .... 27.
+5v @ 1 Amp. + 12v @ .5 Amp. − 12v @ 50 ma.
UPS03 Assembled & Tested .... 60.
UPS04 Complete Kit .... 50.

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Items Reviewed

CP/M-68K $350
Digital Research
POB 579
Pacific Grove, CA 93950
(408) 649-3896

Epson FX-80 Printer $699
Epson QX-10 Computer with 64K-byte RAM $2495
with 128K-byte RAM $2995
Epson America Inc.
Computer Products Division
3415 Kashiwa St.
Torrance, CA 90505
(213) 539-9140

JRT Pascal $29.95
JRT Systems
45 Camino Alto
Mill Valley, CA 94941
(415) 388-0530

Zenith Z-29 Terminal $849
Zenith Data Systems
1000 Milwaukee Ave.
Glenview, IL 60025
(312) 391-8865

Book Reviewed

Word Processing Buyer's Guide $15.95
Arthur Naiman. Hightstown, NJ: BYTE/McGraw-Hill, 1983, softcover

some time and likes it.

I like it too. My quarrel with VEDIT is that the installation and customization procedures are darned complex: in the version that was sent me, you had to answer 34 questions, and if you made a single mistake while doing it (not even Backspace was permitted for correcting the answers you had to give!) you had to start all over. I complained—bitterly—and the last I heard the VEDIT people were rewriting those procedures to make them easier to use.

I have two editors I can use on the Zenith Z-100: VEDIT and Superwriter. Both are very nice, and I hope to report on each in a future column. Meanwhile, several readers have written to praise VEDIT. The VEDIT philosophy is to have *tons* of special functions, so that each of the myriad special-function keys on the Telewidget can be made to do something special; as Mr. Lawler says, you can get "touch editing." This can be pretty useful, especially in a programming editor.

Philippe Malarme of Brussels, Belgium, writes: "On different occasions you complained in BYTE about poor and overpriced documentation, but I don't think you've met a worse case than Supersoft's Ada . . . their 'document' consists of a Xerox copy of the Department of Defense Ada specifications (1980 version) and *Ada Supersoft User's Manual*, a book of 30 pages!

"The worst is yet to come: of the 30 pages, 2 are a 'software agreement' which disclaims any warranty or responsibility . . . and three list 'Standard Ada unimplemented features.' . . . Their compiler is an Ada subset the way Sinclair's ZX81 is a subset of the Cray-1 computer."

I don't have Supersoft Ada, but P. Malarme's letter is typical of those I've received from those who've bought it.

James Tower writes in behalf of a number of computer users in Germany, where they are condemned to 50-Hz power at 220 volts. Tower had decided on a Lobo Max-80 computer, when he discovered that Lobo won't guarantee that it can work with a 50-Hz power source. The monitor seems to be the major problem: the company is afraid the display will "swim." Moreover, Lobo doesn't want to guarantee a machine in Europe because it would have to reimport it if something went wrong.

Mr. Tower paints a pretty gloomy picture of what it must be like on the continent just now. Most products aren't available, and those that are seem overpriced. He thinks Lobo would have a very clear field, even at prices well above those currently advertised, if they had a package deal for export to Germany.

I can sympathize with Tower without knowing what to do. One of the few serious complaints I've had about Godbout/Compupro came from a German purchaser. Communications take forever, and shipping equipment back and forth is very expensive.

In any event, Mr. Tower wonders if there might be a simple solution to the problem of adapting a Lobo Max-80 to eat German electricity and still deliver stable video output. That seems more in Ciarcia's department than mine; perhaps Steve can answer. Meanwhile, I can report that Barry Workman continues to rely on his Lobo Max-80 as one of his principal machines; Ralph will read a wide variety of disk formats and has given him no trouble at all.

Some months are worse than others: this month I got bales of mail, and I'll hardly be able to answer any of it, what with all the other demands on my time. April *is* the cruelest month . . .■

Jerry Pournelle welcomes readers' comments and opinions. Send a self-addressed, stamped envelope to Jerry Pournelle, c/o BYTE Publications, POB 372, Hancock, NH 03449. Please put your address on the letter as well as on the envelope. Due to the high volume of letters, Jerry cannot guarantee a personal reply.

Jerry Pournelle is a former aerospace engineer and current science-fiction writer who loves to play with computers.

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Voice Lab

Part 2: Menu-Driven Routines for Digital Speech Synthesis and Analysis

UCSD Pascal units form a modular voice workbench

by John E. Hoot

In part 1 (July, page 186) we looked at the theory behind the operation of the Voice Lab system. This month, we'll see how it works in practice.

Voice Lab Operation

The experimenter's interface to Voice Lab is menu-driven and highly interactive. Like any workbench, it was constructed to keep the tools handy and to minimally constrain what is constructed. (For a review of the functions of different Voice Lab units, see table 1.)

When the main program, shown in listing 1, is first executed, the primary function menu appears across the top of the screen in the usual style associated with the UCSD p-System. The options presented are

Voice Lab:
D(ictionary
R(ecord & listen
S(tatistics
M(essages
F(ilter
Q(uit

By striking one character (the one preceding the parenthesis) you may select the desired subsidiary screen menu. Typically, a subsidiary screen's resulting data is not erased when you return to the primary menu, but you may erase it by typing a space. Now let's take a look at how the program's subsidiary menu screens operate.

Dictionary

When the dictionary menu is selected, the unit (listing 2) displays a prompt line at the top of the display indicating the available options:

Dictionary:
D)irectory
R)emove
A)ppend
I)nsert
C)lear
Q)uit

Typing the character preceding the parenthesis selects the desired option. Pressing the space bar will erase any information remaining on the screen from a previous operation.

The Directory option displays the contents of the current vocabulary in three columns. The left-hand column contains an index to the vocabulary word, the middle column contains the word, and the right-hand column displays the size in bytes of the encoded speech segment stored for that word. Table 4 in part 1 (July, page 196) showed a segment of the sample output from this command.

The Remove command is used to delete unwanted entries from the dictionary.

The Append command is primarily used during speech analysis. Its function is to append to the current contents of the speech buffer a word or phrase stored in the dictionary. By using Append, you can assemble a phrase in the speech buffer for study. For instance, you could append the words "how," "are," and "you" to obtain the phrase "How are you."

The Insert command adds the contents of the speech buffer to the dictionary. The example below illustrates how to insert the word "through" and its homonyms into the dictionary, presuming that the word has already been captured in the speech buffer. Both the computer's output and the user's input are shown.

Numbering of figures and tables is continued from Part 1.

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p-System is a trademark of Softech Microsystems, Inc.

I

Word or phrase name:through*Return*
Enter Homonym :thru*Return*
Enter Homonym :threw*Return*
Enter Homonym :*Return*

When you answer the final prompt with just the Return key, the word and all of its homonyms will be added to the dictionary. The program then replies:

THROUGH, THRU, THREW add-*ed to dictionary.*

The Clear command disposes of the entire dictionary. It allows you to discard your present dictionary and begin to build a completely new one. If you select this function, the program double-checks your intent.

The Quit command from the dictionary screen returns the program to the main prompt menu.

Analog I/O Unit
- services provided:
  - analog output from the speech buffer
  - digitizing speech into the speech buffer
- resources provided:
  - 16K-byte speech buffer
  - tempo-rate variable

Voice Dictionary Unit
- services provided:
  - vocabulary word look-up
  - vocabulary word insertion
  - vocabulary word deletion
  - vocabulary word retrieval
  - dictionary erasure

Voice Messages Unit
- services provided:
  - word-to-speech output
  - string-to-speech output

Voice Display Unit
- services provided:
  - zero-crossing counts and plots
  - spectral-energy plots
  - total speech-energy plots
  - signal-level monitoring

Voice Filter Unit
- service provided:
  - interactive linear digital filtering

Table 1: *Summary of functions of Voice Lab units (repeated from part 1).*

Record and Listen Menu

The Record and Listen menu, shown in figure 6 on page 469, controls the functions in which audio speech segments are captured and then played back. Its functions can isolate words or phrases from the speech buffer and control sampling rates for D/A (digital to analog) and A/D (analog to digital) conversion.

The Set Tempo item in the menu controls the rate of playback and recording digitization. Depending on exactly how the Analog I/O unit works in your system, the default rate may require modification. Recording at a normal rate and playing back at a higher rate has the same effect as listening to a 45-rpm phonograph record at 78 rpm. If your intent is to produce normal speech, you should always play back at the same rate as you recorded the input. You can vary the tempo to discover the minimum sampling rate that produces acceptable speech on your system.

The Beginning and End menu items each set one of two indexes that delineate the portion of the speech buffer upon which the program will operate. All operations in Voice Lab are bound by these indexes. As an example, you might originally set the Beginning parameter to 0 and the End parameter to 9999 (using the whole buffer), and record the phrase "one, two, three." By adjusting Beginning and End to 2800 and 3500, respectively, you might isolate the word "two" in the speech buffer.

The Record operation causes the following prompt to be displayed in the upper left-hand corner of the display:

Hit <ret> then speak

You can synchronize the beginning of your speech with the beginning of the digitization process. Upon completion of digitization, this prompt is replaced by the response:

Done!

The Play function reconstructs the contents of the speech buffer through the A/D converter on your computer.

Upon quitting the Record and Listen menu, all the information on the screen and in the speech buffer is preserved. Thus, assuming that the speech buffer contains the word "two," you could enter the dictionary menu and append the word "go" to the speech buffer; this would increment the End index of the speech buffer and leave the speech buffer containing the phrase "two go."

Statistics Menu

The Statistics menu controls the generation of the plots by the Voice Display Unit (listing 3). The options of the main statistics screen are as follows:

Stats:
E(nergy & Crosses
P(lot
A(vg
M(ax & min
S(pectrum
Q(uit

Text continued on page 469

Listing 1: *The main program Voice_lab, written in UCSD Pascal to use the p-System units for performing specific functions.*

```
Pascal Compiler IV.1 c5s-4      3/27/83

 2   1:d   1  Program Voice_lab;
 2   1:d   1  {--------------------------------------------}
 2   1:d   1  {                                            }
 2   1:d   1  {   VOICELAB INTERACTIVE SPEECH ANALYSIS     }
 2   1:d   1  {                 UTILITY                    }
 2   1:d   1  {                                            }
 2   1:d   1  {   [C]opyright John E. Hoot 1983. All rights }
 2   1:d   1  {       reserved                             }
 2   1:d   1  {                                            }
 2   1:d   1  {--------------------------------------------}
 2   1:d   1

              Using SCREENOP
 2   1:u   1
 2   1:u   1  const
 2   1:u   1     sc_fill_len = 11;
 2   1:u   1     sc_eol = 13;
 2   1:u   1
 2   1:u   1  type
 2   1:u   1     sc_chset        = set of char;
 2   1:u   1     sc_misc_rec     = packed record
 2   1:u   1                         height, width : 0..255;
 2   1:u   1                         can_break, slow, xy_crt, lc_crt,
 2   1:u   1                         can_upscroll, can_downscroll : boolean;
 2   1:u   1                       end;
 2   1:u   1     sc_date_rec     = packed record
 2   1:u   1                         month : 0..12;
 2   1:u   1                         day :   0..31;
 2   1:u   1                         year :  0..99;
 2   1:u   1                       end;
 2   1:u   1     sc_info_type    = packed record
 2   1:u   1                         sc_version : string;
 2   1:u   1                         sc_date : sc_date_rec;
 2   1:u   1                         spec_char : sc_chset; {Characters not to echo}
 2   1:u   1                         misc_info : sc_misc_rec;
 2   1:u   1                       end;
 2   1:u   1     sc_long_string  = string[255];
 2   1:u   1     sc_scrn_command = (sc_whome, sc_eras_s, sc_erase_eol, sc_clear_lne,
 2   1:u   1                        sc_clear_scn, sc_up_cursor, sc_down_cursor,
 2   1:u   1                        sc_left_cursor, sc_right_cursor);
 2   1:u   1     sc_key_command  = (sc_backspace_key, sc_dc1_key, sc_eof_key, sc_etx_key,
 2   1:u   1                        sc_escape_key, sc_del_key, sc_up_key, sc_down_key,
 2   1:u   1                        sc_left_key, sc_right_key, sc_not_legal);
 2   1:u   1     sc_choice       = (sc_get, sc_give);
 2   1:u   1     sc_window       = packed array [0..0] of char;
 2   1:u   1     sc_tx_port      = record
 2   1:u   1                         row, col,           { screen relative}
 2   1:u   1                         height, width,      { size of txport (zero based)}
 2   1:u   1                         cur_x, cur_y  : integer;
 2   1:u   1                                 {cursor positions relative to the txport }
 2   1:u   1                       end;
 2   1:u   1
 2   1:u   1    procedure sc_use_info(do_what:sc_choice; var t_info:sc_info_type);
 2   1:u   1    procedure sc_use_port(do_what:sc_choice; var t_port:sc_tx_port);
 2   1:u   1    procedure sc_erase_to_eol(x,line:integer);
 2   1:u   1    procedure sc_left;
 2   1:u   1    procedure sc_right;
 2   1:u   1    procedure sc_up;
 2   1:u   1    procedure sc_down;
 2   1:u   1    procedure sc_getc_ch(var ch:char; return_on_match:sc_chset);
 2   1:u   1    procedure sc_clr_screen;
 2   1:u   1    procedure sc_clr_line (y:integer);
 2   1:u   1    procedure sc_home;
 2   1:u   1    procedure sc_eras_eos (x,line:integer);
 2   1:u   1    procedure sc_goto_xy(x, line:integer);
 2   1:u   1    procedure sc_clr_cur_line;
 2   1:u   1    function  sc_find_x:integer;
 2   1:u   1    function  sc_find_y:integer;
 2   1:u   1    function  sc_scrn_has(what:sc_scrn_command):boolean;
 2   1:u   1    function  sc_has_key(what:sc_key_command):boolean;
 2   1:u   1    function  sc_map_crt_command(var k_ch:char):sc_key_command;
 2   1:u   1    function  sc_prompt(line :sc_long_string; x_cursor,y_cursor,x_pos,
 2   1:u   1                        where:integer; return_on_match:sc_chset;
 2   1:u  21                        no_char_back:boolean; break_char:char):char;
 2   1:u   1    function sc_check_char(var buf:sc_window; var buf_index,bytes_left:integer)
 2   1:u                                 :boolean;
 2   1:u   1    function space_wait(flush:boolean):boolean;
 2   1:u   1    procedure sc_init;
 2   1:u   1
 2   1:d   1     uses {$U Screenops.code} screenops,

              Using VOICEDIC
 2   1:u   1
 2   1:u   1  {------------------------------------------}
 2   1:u   1  {                                          }
 2   1:u   1  {      VOICELAB VOCABULARY DICTIONARY      }
 2   1:u   1  {            MANAGEMENT UNIT               }
 2   1:u   1  {                                          }
 2   1:u   1  {  [C]opyright John E. Hoot 1983. All rights }
 2   1:u   1  {     reserved                             }
 2   1:u   1  {                                          }
 2   1:u   1  {------------------------------------------}
 2   1:u   1
 2   1:u   1     type dict_result=(successful,buf_oflow, not_found,
 2   1:u   1                       dict_full,dup_entry,index_oflow);
 2   1:u   1
 2   1:u   1     function find_word( name:string; var idx:integer ): boolean;
 2   1:u   1
 2   1:u   1     function index_word( idx:integer; var name:string;
 2   1:u                            var ln:integer  ) : boolean;
 2   1:u   1
 2   1:u   1     function insert_words( s:string ) : dict_result;
 2   1:u   1
 2   1:u   1     function append_word( name:string ) :  dict_result;
 2   1:u   1
 2   1:u   1     function remove_word( name:string ) : dict_result;
 2   1:u   1
 2   1:u   1     procedure clear_dictionary;
 2   1:u   1
 2   1:d   1        {$U Voice.dict.code} voice_dictionary,

              Using VOICEMSC
 2   1:u   1
 2   1:u   1  {------------------------------------------}
 2   1:u   1  {                                          }
```

Listing 1 continued on page 460

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Listing 1 continued:

```
2   1:u   1  {        VOICELAB TEXT-TO-SPEECH OUTPUT         }
2   1:u   1  {                SERVICE UNIT                   }
2   1:u   1  {                                               }
2   1:u   1  {  (C)opyright John E. Hoot 1983. All rights    }
2   1:u   1  {      reserved                                 }
2   1:u   1  {                                               }
2   1:u   1  {-----------------------------------------------}
2   1:u   1
2   1:u   1       function speakword( s:string ): boolean;
2   1:u   1       procedure speakline( ln:string );
2   1:u   1
2   1:d   1         {$U Voice.msg.code} voice_msg,

                                          Using VOICEDSP
2   1:u   1
2   1:u   1  {-----------------------------------------------}
2   1:u   1  {                                               }
2   1:u   1  {        VOICELAB PCM SPEECH ANALYSIS UNIT      }
2   1:u   1  {                                               }
2   1:u   1  {  (C)opyright John E. Hoot 1983. All rights    }
2   1:u   1  {      reserved                                 }
2   1:u   1  {                                               }
2   1:u   1  {-----------------------------------------------}
2   1:u   1
2   1:u   1    procedure display;
2   1:u   1
2   1:u   1
2   1:d   1         {$U Voice.dsp.code} voice_dsp,

                                          Using VOICEFIL
2   1:u   1
2   1:u   1  {-----------------------------------------------}
2   1:u   1  {                                               }
2   1:u   1  {   VOICELAB PCM SPEECH RECURSIVE DIGITAL       }
2   1:u   1  {              FILTERING UNIT                   }
2   1:u   1  {                                               }
2   1:u   1  {  (C)opyright John E. Hoot 1983. All rights    }
2   1:u   1  {      reserved                                 }
2   1:u   1  {                                               }
2   1:u   1  {-----------------------------------------------}
2   1:u   1
2   1:u   1    procedure filter;
2   1:u   1
2   1:d   1         {$U Voice.ftr.code} voice_filter,

                                          Using ANALOGIO
2   1:u   1
2   1:u   1  {-----------------------------------------------}
2   1:u   1  {                                               }
2   1:u   1  {        VOICELAB ANALOG INPUT/OUTPUT           }
2   1:u   1  {               SERVICE UNIT                    }
2   1:u   1  {                                               }
2   1:u   1  {  (C)opyright John E. Hoot 1983. All rights    }
2   1:u   1  {      reserved                                 }
2   1:u   1  {                                               }
2   1:u   1  {-----------------------------------------------}
2   1:u   1
2   1:u   1    const vox_buflen = 16383;
2   1:u   1
2   1:u   1  type vox_bufrange = 0..vox_buflen;
2   1:u   1       byte = 0..255;
2   1:u   1       vox_buffer=packed array[vox_bufrange] of byte;
2   1:u   1       vox_ptr = ^vox_buffer;
2   1:u   1
2   1:u   1  var tempo,start,stop:vox_bufrange;
2   1:u   4      stream:vox_ptr;
2   1:u   5
2   1:u   5  procedure ADC( var ptr:vox_buffer;
2   1:u   2                 offset, len: vox_bufrange; rate:integer );
2   1:u   1
2   1:u   1  procedure DAC( var ptr:vox_buffer;
2   1:u                     offset, len:vox_bufrange; rate:integer );
2   1:u   1
2   1:d   1       {$U Analog.io.code} analog_io;
2   1:d   1
2   1:d   1  var c:char;
2   1:d   2
2   1:d   2  procedure message;
2   1:d   1
2   2:d   1     var result,dummy:integer;
2   2:d   3         s:string;
2   2:d  44         c:char;
2   2:d  45         f:text;
2   2:d 346
2   2:0   0     begin
2   2:1  10     sc_clr_screen;
2   2:1  12     repeat
2   2:2  12        c:=sc_prompt('Messages: L(iteral, F(ile, Q(uit '
2   2:2  13        ,-1,0,0,0,
2   2:2  23           ['F','f','L','l','Q','q'],false,',');
2   2:2  38        case c of
2   2:2  43          ' ':sc_clr_screen;
2   2:2  48          'L','l': begin
2   2:4  48                   writeln;
2   2:4  56                   repeat
2   2:5  56                     sc_clr_cur_line;
2   2:5  58                     write('Enter Text: ');
2   2:5  72                     readln(s);
2   2:5  91                     speakline(s);
2   2:4  95                   until s='';
2   2:3 104                   end;
2   2:2 107           'F','f':begin
2   2:2 107                   {$I-}
2   2:4 107                   writeln;
2   2:4 113                   sc_clr_cur_line;
2   2:4 115                   write('Enter filename: ');
2   2:4 127                   readln(s);
2   2:4 142                   reset(f,s);
2   2:4 151                   result:=ioresult;
2   2:4 155                   if result<>0 then
2   2:5 159                      reset(f,concat(s,'.text'));
2   2:4 187                   result:=ioresult;
2   2:4 201                   if result<>0 then
2   2:5 205                      writeln('File not found')
2   2:4 223                   else
2   2:5 225                      begin
2   2:6 225                      while not(eof(f))
2   2:6 231                      do begin
```

Listing 1 continued on page 461

Listing 1 continued:

```
2  2:8  233                    readln(f,s);
2  2:6  246                    speakline(s);
2  2:7  250                    end;
2  2:6  252                  close(f);
2  2:5  258                  end;
2  2:3  258                end;
2  2:2  260              end;
2  2:1  263      until (c='Q') or (c='q');
2  2:1  277      sc_clr_screen;
2  1:0    0      end;
2  1:0    0
2  1:0    0
2  1:d    1  procedure dictionary;
2  3:d    1      var result:dict_result;
2  3:d    2        i,ln,dummy:integer;
2  3:d    5        c,ch:char;
2  3:d    7        done:boolean;
2  3:d    8        s,nm:string;
2  3:d   90
2  3:0    0      begin
2  3:1    0      sc_clr_screen;
2  3:1    2      repeat
2  3:2    2        c:=sc_prompt(concat('Dictionary: D)irectory, R)emove, A)ppend,',
2  3:2   20             ' I)nsert, C)lear Q)uit '),-1,0,0,0,
2  3:2   38             ['d','r','a','i','c','q','D','R','A','I','C','Q',' '],
2  3:2   46             false,',');
2  3:2   52        case c of
2  3:2   56          'D','d':begin
2  3:4   56              i:=1;
2  3:4   56              writeln;
2  3:4   64              done:=false;
2  3:4   66              while (not done) and index_word( i,s, ln )
2  3:4   73              do begin
2  3:6   78                writeln(i:3,s:20,ln:10);
2  3:6  110                i:=i+1;
2  3:6  113                if (i mod 23)=23 then
2  3:7  123                  begin
2  3:8  123                  if not space_wait(false) then
2  3:9  129                    done:=true
2  3:8  129                  else sc_clr_screen;
2  3:8  135                  writeln;
2  3:7  141                  end;
2  3:5  141                end;
2  3:4  143              if not done then
2  3:5  146                write('Dictionary consteins ',i-1,' entries.');
2  3:3  179              end;
2  3:2  182          'R','r':begin
2  3:4  182              sc_clr_screen;
2  3:4  184              write('Remove what word? ');
2  3:4  196              readln(s);
2  3:4  212              if s<>'' then
2  3:5  222                begin
2  3:6  222                result:=remove_word(s);
2  3:6  229                case result of
2  3:6  232                  successful: writeln(s,' removed.');
2  3:6  262                  not_found: writeln(s,' not in dictionary.');
2  3:6  292                  end;
2  3:5  295                end;
2  3:3  295              end;
2  3:2  298          'I','i':begin
2  3:4  298              sc_clr_screen;
2  3:4  300              write('Word or phrase name: ');
2  3:4  312              s:='';
2  3:4  320              repeat
2  3:5  320                readln(nm);
2  3:5  335                if nm<>'' then
2  3:6  344                  begin
2  3:7  344                  s:=concat(s,nm,',');
2  3:7  385                  write('Enter Homonym :');
2  3:6  397                  end;
2  3:4  397              until nm='';
2  3:4  406              if s<>'' then
2  3:5  416                case insert_words( s ) of
2  3:5  424                  successful:writeln(s,' added to dictionary.');
2  3:5  454                  dup_entry:writeln('Words(s) already defined.');
2  3:5  474                  dict_full:writeln('Dictionary file is full. ');
2  3:5  494                  index_oflow:writeln('Dictionary table overvlow.');
2  3:5  514                  end;
2  3:3  517              end;
2  3:2  520          'C','c':begin
2  3:4  520              sc_clr_screen;
2  3:4  522              write('Do really wish to erase the dictionary? ');
2  3:4  534              read(ch);
2  3:4  541              if (ch='y') or (ch='Y') then
2  3:5  552                begin
2  3:6  552                clear_dictionary;
2  3:6  554                writeln;
2  3:6  560                write('Dictionary Erased.');
2  3:5  572                end;
2  3:3  572              end;
2  3:2  575          'A','a':begin
2  3:4  575              sc_clr_screen;
2  3:4  577              write('Append what word to buffer: ');
2  3:4  589              readln(s);
2  3:4  605              case append_word( s ) of
2  3:4  613                successful:writeln(s,'dded to buffer.');
2  3:4  643                not_found:writeln('Could not find ',s,'.');
2  3:4  682                buf_oflow:writeln('Not enough room in buffer. ',
2  3:5  694                               vox_buflen-stop,' bytes remain.');
2  3:4  728                end;
2  3:3  731              end;
2  3:2  733          ' ': sc_clr_screen;
2  3:2  737          end;
2  3:1  740      until (c='q') or (c='Q');
2  1:0    0      end;
2  1:0    0
2  1:0    0
2  1:d    1  procedure record_listen;
2  4:d    1      var c:char;
2  4:0    0      begin
2  4:1    0      sc_clr_screen;
2  4:1    2      gotoxy(25,5);  write('S(et tempo  ',tempo);
2  4:1   29      gotoxy(25,6);  write('B(eginning  ',start);
2  4:1   56      gotoxy(25,7);  write('E(nd        ',stop);
2  4:1   83      gotoxy(25,8);  write('R(ecord     ');
2  4:1  100      gotoxy(25,9);  write('P(lay');
2  4:1  117      gotoxy(25,10); write('Q(uit');
2  4:1  134      repeat
```

Listing 1 continued on page 462

Listing 1 continued:

```
2   4:2 134          gotoxy(0,0);
2   4:2 139          read(keyboard,c);
2   4:2 146          case c of
2   4:2 150            'R','r':begin
2   4:4 150                    gotoxy(0,0);
2   4:4 155                    memlock('ANALOGIO');
2   4:4 163                    write('Hit <ret> then speak');
2   4:4 175                    readln;
2   4:4 181                    adc(STREAM^,start,stop-start,tempo);
2   4:4 209                    writeln('Done!');
2   4:4 227                    memswap('ANALOGIO');
2   4:4 235                    gotoxy(0,0);
2   4:4 240                    write('                          ');
2   4:3 252                    end;
2   4:2 255            'P','p':dac(stream^,start,stop-start,tempo);
2   4:2 285            'S','s':begin
2   4:4 285                    gotoxy(37,5);
2   4:4 291                    write('                 ');
2   4:4 303                    gotoxy(37,5);
2   4:4 309                    readln(tempo);
2   4:3 324                    end;
2   4:2 326            'B','b':begin
2   4:4 326                    gotoxy(37,6);
2   4:4 332                    write('                 ');
2   4:4 344                    gotoxy(37,6);
2   4:4 350                    readln(start);
2   4:3 365                    end;
2   4:2 367            'E','e':begin
2   4:4 367                    gotoxy(37,7);
2   4:4 373                    write('                 ');
2   4:4 385                    gotoxy(37,7);
2   4:4 391                    readln(stop);
2   4:3 406                    end;
2   4:2 408            end;
2   4:2 411          if not( c in ['R','r','S','s','B','b','E','e','Q','q','P','p'])
2   4:2 419          then write(chr(7));
2   4:1 429        until ('Q'=c) or ('q'=c);
2   4:1 441        sc_clr_screen;
2   1:0   0        end;
2   1:0   0
2   1:0   0      begin (voicelab)
2   1:1   0      repeat
2   1:2   0        c:=sc_prompt( concat('Voicelab: D(ictionary, R(ecord',
2   1:2  17        ' & listen, S(tatisitics, M(essage, F(ilter, Q(uit '),
2   1:2  30              -1,0,0,0,
2   1:2  35   ['m','d','r','l','s','f','q','M','D','R','L','S','F','Q',' '],
2   1:2  43              false,',');
2   1:2  50        case c of
2   1:2  53          ' ':sc_clr_screen;
2   1:2  57          'D','d': dictionary;
2   1:2  61          'R','r': record_listen;
2   1:2  65          'S','s': display;
2   1:2  69          'F','f': filter;
2   1:2  73          'M','m': message;
2   1:2  77          end;
2   1:1  80      until (C='q') or (C='Q');
2    :0   0      end (voicelab).
```

End of Compilation.

Listing 2: *The Voice Dictionary unit (Voice_dictionary), which provides all speech-storage and speech-retrieval functions for Voice Lab.*

```
Pascal Compiler IV.1 c5s-4      3/27/83

2   1:d   1  Unit Voice_dictionary;
2   1:d   1
2   1:d   1  Interface
2   1:d   1  {----------------------------------------------------}
2   1:d   1  {                                                    }
2   1:d   1  {          VOICELAB VOCABULARY DICTIONARY            }
2   1:d   1  {                 MANAGEMENT UNIT                    }
2   1:d   1  {                                                    }
2   1:d   1  {   (C)opyright John E. Hoot 1983. All rights        }
2   1:d   1  {        reserved                                    }
2   1:d   1  {                                                    }
2   1:d   1  {----------------------------------------------------}
2   1:d   1
2   1:d   1    type dict_result=(successful,buf_oflow, not_found,
2   1:d   1                      dict_full,dup_entry,index_oflow);
2   1:d   1
2   1:d   1    function find_word( name:string; var idx:integer ): boolean;
2   1:d   1
2   1:d   1    function index_word( idx:integer; var name:string;
2   1:d                              var ln:integer  ) : boolean;
2   1:d   1
2   1:d   1    function insert_words( s:string ) : dict_result;
2   1:d   1
2   1:d   1    function append_word( name:string ) :  dict_result;
2   1:d   1
2   1:d   1    function remove_word( name:string ) : dict_result;
2   1:d   1
2   1:d   1    procedure clear_dictionary;
2   1:d   1
2   1:d   1  Implementation
2   1:d   1

             Using ANALOGIO
2   1:u   1
2   1:u   1  {----------------------------------------------------}
2   1:u   1  {                                                    }
2   1:u   1  {          VOICELAB ANALOG INPUT/OUTPUT              }
2   1:u   1  {                 SERVICE UNIT                       }
2   1:u   1  {                                                    }
2   1:u   1  {   (C)opyright John E. Hoot 1983. All rights        }
2   1:u   1  {        reserved                                    }
2   1:u   1  {                                                    }
2   1:u   1  {----------------------------------------------------}
2   1:u   1
2   1:u   1    const vox_buflen = 16383;
2   1:u   1
2   1:u   1    type vox_bufrange = 0..vox_buflen;
2   1:u   1         byte = 0..255;
2   1:u   1         vox_buffer=packed array[vox_bufrange] of byte;
2   1:u   1         vox_ptr = ^vox_buffer;
2   1:u   1
2   1:u   1    var tempo,start,stop:vox_bufrange;
2   1:u   4        stream:vox_ptr;
2   1:u   5
```

Listing 2 continued on page 463

Listing 2 continued:

```
2    1:u    5    procedure ADC( var ptr:vox_buffer;
2    1:u    2                  offset, len: vox_bufrange; rate:integer );
2    1:u    1
2    1:u    1    procedure DAC( var ptr:vox_buffer;
2    1:u                      offset, len:vox_bufrange; rate:integer );
2    1:u    1
2    1:d    1    Uses {$U analog.io.code} analog_io;
2    1:d    1
2    1:d    1    const dict_size = 169;
2    1:d    1    type word_dict=
2    1:d    1            array[0..dict_size] of
2    1:d    1               record
2    1:d    1                  word:string[7];
2    1:d    1                  len,blk:integer;
2    1:d    1                end;
2    1:d    1
2    1:d    1    Var dummy:integer;
2    1:d    2       lib:file;
2    1:d   42       dict:^word_dict;
2    1:d   43
2    1:d   43    procedure upcase( var s:string );
2    8:d    1      var i:integer;
2    8:0    0      begin
2    8:1    0      for i:=1 to length(s)
2    8:1    4      do if s[i] in ['a'..'z'] then
2    8:3   24            s[i]:=chr(ord(s[i])-32);
2    1:0    0      end;
2    1:0    0
2    1:d    1    function find_word(name:string; var idx:integer ):boolean );
2    2:d    1       var i:integer;
2    2:0    0       begin
2    2:1    6       upcase(name);
2    2:1   10       if length(name)>7 then
2    2:2   18         name:=copy(name,1,7);
2    2:1   32       find_word:=false;
2    2:1   35       if dict^[0].blk<>1 then
2    2:2   48         begin
2    2:3   48         for i:=1 to dict^[0].blk-1
2    2:3   59         do if name=dict^[i].word then
2    2:5   83              begin
2    2:6   83              idx:=i;
2    2:6   87              find_word:=true;
2    2:6   90              exit(find_word);
2    2:5   95              end;
2    2:2  100         end;
2    1:0    0       end;
2    1:0    0
{commented ';'}  function index_word( idx:integer; var name:string;
2    1:d    1                            var len:integer ):boolean);
2    3:0    0
2    3:1    0       begin
2    3:1    2       index_word:=false;
2    3:2   16       if idx<dict^[0].blk then
2    3:3   26         with dict^[idx] do
2    3:4   26            begin
2    3:4   31            name:=word;
2    3:4   35            ln:=len;
2    3:3   37            index_word:=true;
2    1:0    0            end;
2    1:0    0       end;
2    1:0    0
2    1:0    0
2    1:d    1    function remove_word( name : string ) : dict_result);
2    6:d    1       var i,j,k,l,src,ln:integer;
2    6:0    0       begin
2    6:1    5       remove_word:=not_found;
2    6:1    8       if find_word( name, i) then
2    6:2   17          begin
2    6:3   17          while (i>1) and
2    6:3   21               (dict^[i-1].blk=dict^[i].blk)
2    6:3   43          do i:=i-1;
2    6:3   51          j:=i;
2    6:3   53          while dict^[i].blk=dict^[j].blk
2    6:3   72          do j:=j+1;
2    6:3   80          src:=dict^[j].blk;
2    6:3   91          l:=src-dict^[i].blk;
2    6:3  104          dict^[dict^[0].blk].word:='';
2    6:3  128          while j<=dict^[0].blk
2    6:3  138          do begin
2    6:5  142             dict^[i].word:=dict^[j].word;
2    6:5  163             dict^[i].len:=dict^[j].len;
2    6:5  185             dict^[i].blk:=dict^[j].blk-l;
2    6:5  209             i:=i+1;
2    6:5  212             j:=j+1;
2    6:4  215             end;
2    6:3  217          dict^[0].blk:=dict^[0].blk+i-j;
2    6:3  243          k:=dict^[dict^[0].blk].blk;
2    6:3  263          dummy:=blockwrite(lib,dict^,4,0);
2    6:3  278          ln:=4;
2    6:3  280          while (src-l)<k
2    6:3  283          do begin
2    6:5  287             if k-src+l<4 then ln:=k-src+l;
2    6:5  302             dummy:=blockread(lib,dict^,ln,src);
2    6:5  317             dummy:=blockwrite(lib,dict^,ln,src-l);
2    6:5  334             src:=src+4;
2    6:4  338             end;
2    6:3  340          dummy:=blockread(lib,dict^,4,0);
2    6:3  355          remove_word:=successful;
2    6:3  358          exit(remove_word);
2    6:2  363          end;
2    1:0    0       end;
2    1:0    0
2    1:d    1    procedure clear_dictionary;
2    7:0    0      begin
2    7:1    0      with dict^[0]
2    7:1    9      do begin
2    7:3   10         blk:=1;
2    7:3   15         dict^[1].blk:=4;
2    7:3   28         dummy:=blockwrite(lib,dict^,4,0);
2    7:2   43         end;
2    1:0    0      end;
2    1:0    0
2    1:0    0
2    1:d    1    function insert_words( s:string ) : dict_result];
2    4:d    1       var i,j,k,next:integer;
2    4:d    5          dup,firstime:boolean;
2    4:d    7          name:string;
2    4:0    0       begin
2    4:1    7       dup:=false;
2    4:1    9       firstime:=true;
```

Listing 2 continued on page 464

Listing 2 continued:

```
173  2   4:1  11     repeat
174  2   4:2  11        i:=1;
175  2   4:2  13        {$R-}
176  2   4:2  13        while (i<=length(s)) and (s[i]<>',')
177  2   4:2  26        do i:=i+1;
178  2   4:2  34        name:=copy(s,1,i-1);
179  2   4:2  50        if s<>'' then delete(s,1,i);
180  2   4:2  66        upcase(name);
181  2   4:2  69        {$R+}
182  2   4:2  69        if length(name)>7 then
183  2   4:3  76           name:=copy(name,1,7);
184  2   4:2  90        if dict^[0].blk<>1 then
185  2   4:3 103           begin
186  2   4:4 103           for i:=1 to dict^[0].blk-1
187  2   4:4 114           do if name=dict^[i].word then
188  2   4:6 139                 begin
189  2   4:7 139                 insert_words:=dup_entry;
190  2   4:7 143                 if firstime then exit(insert_words)
191  2   4:7 151                 else dup:=true;
192  2   4:6 155                 end;
193  2   4:3 160           end;
194  2   4:2 160        if dict^[0].blk>dict_size then
195  2   4:3 175           begin
196  2   4:4 175           insert_words:=index_oflow;
197  2   4:4 179           exit(insert_words);
198  2   4:3 184           end;
199  2   4:2 184        next:=dict^[0].blk;
200  2   4:2 195        if not dup then
201  2   4:3 200           begin
202  2   4:4 200           with dict^[next]
203  2   4:4 209           do begin
204  2   4:6 211                len:=stop-start;
205  2   4:6 223                word:=name;
206  2   4:6 229                i:=(len+511) div 512;
207  2   4:6 241                if firstime then
208  2   4:7 244                   begin
209  2   4:8 244                   dummy:=blockwrite(lib,stream^[start],
210  2   4:8 258                                i,blk);
211  2   4:8 269                   if dummy<>i then
212  2   4:9 273                      begin
213  2   4:0 273                      insert_words:=dict_full;
214  2   4:0 277                      exit(insert_words);
215  2   4:9 282                      end;
216  2   4:8 282                   dict^[next+1].blk:=blk+i;
217  2   4:7 300                   end
218  2   4:6 300                else
219  2   4:7 302                   begin
220  2   4:8 302                   dict^[next+1].blk:=blk;
221  2   4:8 318                   blk:=blk-1;
222  2   4:7 328                   end;
223  2   4:6 328                dict^[0].blk:=next+1;
224  2   4:6 342                dummy:=blockwrite(lib,dict^,4,0);
225  2   4:5 357                end;
226  2   4:3 357           end;
227  2   4:2 357        dup:=false;
228  2   4:2 359        firstime:=false;
229  2   4:1 361     until s='';
230  2   4:1 372     insert_words:=successful;
231  2   1:0   0     end;
232  2   1:0   0
233  2   1:d   1  function append_word( name:string) : dict_result];
234  2   5:d   1    var i,j,k,next:integer;
235  2   5:0   0    begin
236  2   5:1   6    upcase(name);
237  2   5:1  10    if length(name)>7 then
238  2   5:2  18       name:=copy(name,1,7);
239  2   5:1  32    if dict^[0].blk<>1 then
240  2   5:2  47       begin
241  2   5:3  47       for i:=1 to dict^[0].blk-1
242  2   5:3  58       do if name=dict^[i].word then
243  2   5:5  82             with dict^[i]
244  2   5:5  91             do begin
245  2   5:7  92                if len+stop>(16383-511) then
246  2   5:8 108                   begin
247  2   5:9 108                   append_word:=buf_oflow;
248  2   5:9 111                   exit(append_word);
249  2   5:8 116                   end;
250  2   5:7 116                dummy:=blockread(lib,stream^[stop],
251  2   5:7 130                       (len+511) div 512,blk);
252  2   5:7 148                stop:=stop+len;
253  2   5:7 163                append_word:=successful;
254  2   5:7 166                exit(append_word);
255  2   5:6 171                end;
256  2   5:2 176       end;
257  2   5:1 176    append_word:=not_found;
258  2   1:0   0    end;
259  2   1:0   0
260  2   1:0   0  begin {voice_dictionary}
261  2   1:0   0  {$I-}
262  2   1:1   9  reset(lib,'voice.dict');
263  2   1:1  20  {$I+}
264  2   1:1  20  if ioresult<>0 then
265  2   1:2  26     begin
266  2   1:3  26     rewrite(lib,'Voice.dict');
267  2   1:3  39     dummy:=varnew(dict,1024);
268  2   1:3  49     clear_dictionary;
269  2   1:2  51     end
270  2   1:1  51  else dummy:=varnew(dict,1024);
271  2   1:1  63  dummy:=blockread(lib,dict^,4,0);
272  2   1:1  78  ***;
273  2   1:1  80  vardispose(dict,1024);
274  2   1:1  87  close(lib,lock);
275  2    :0   0  end.{Voice dictionary}

End of Compilation.
```

Listing 3: *The Voice Display (Voice_dsp) unit, which displays graphical information describing the contents of the speech buffer. It contains routines specific to the type of printer being used.*

```
Pascal Compiler IV.1 c5s-4      3/27/83

   1  2   1:d   1  Unit Voice_dsp;
   2  2   1:d   1
   3  2   1:d   1  Interface
   4  2   1:d   1  {-------------------------------------------------}
   5  2   1:d   1  {                                                 }
   6  2   1:d   1  {        VOICELAB PCM SPEECH ANALYSIS UNIT        }
```

Listing 3 continued on page 465

Listing 3 continued:

```
 2  1:d   1  {                                              }
 2  1:d   1  {   (C)opyright John E. Hoot 1983. All rights  }
 2  1:d   1  {       reserved                               }
 2  1:d   1  {                                              }
 2  1:d   1  {----------------------------------------------}
 2  1:d   1
 2  1:d   1     procedure display;
 2  1:d   1
 2  1:d   1
 2  1:d   1  Implementation
 2  1:d   1

             Using ANALOGIO
 2  1:u   1
 2  1:u   1  {----------------------------------------------}
 2  1:u   1  {                                              }
 2  1:u   1  {         VOICELAB ANALOG INPUT/OUTPUT         }
 2  1:u   1  {                SERVICE UNIT                  }
 2  1:u   1  {                                              }
 2  1:u   1  {   (C)opyright John E. Hoot 1983. All rights  }
 2  1:u   1  {       reserved                               }
 2  1:u   1  {                                              }
 2  1:u   1  {----------------------------------------------}
 2  1:u   1
 2  1:u   1     const vox_buflen = 16383;
 2  1:u   1
 2  1:u   1     type vox_bufrange = 0..vox_buflen;
 2  1:u   1          byte = 0..255;
 2  1:u   1          vox_buffer=packed array[vox_bufrange] of byte;
 2  1:u   1          vox_ptr = ^vox_buffer;
 2  1:u   1
 2  1:u   1     var tempo,start,stop:vox_bufrange;
 2  1:u   4         stream:vox_ptr;
 2  1:u   5
 2  1:u   5     procedure ADC( var ptr:vox_buffer;
 2  1:u   2                 offset, len: vox_bufrange; rate:integer );
 2  1:u   1
 2  1:u   1     procedure DAC( var ptr:vox_buffer;
 2  1:u                     offset, len:vox_bufrange; rate:integer );
 2  1:u   1
 2  1:d   1     uses {$U analog.io.code} analog_io,

             Using SCREENOP
 2  1:u   1
 2  1:u   1  const
 2  1:u   1      sc_fill_len = 11;
 2  1:u   1      sc_eol = 13;
 2  1:u   1
 2  1:u   1  type
 2  1:u   1      sc_chset        = set of char;
 2  1:u   1      sc_misc_rec     = packed record
 2  1:u   1                          height, width : 0..255;
 2  1:u   1                          can_break, slow, xy_crt, lc_crt,
 2  1:u   1                          can_upscroll, can_downscroll : boolean;
 2  1:u   1                        end;
 2  1:u   1      sc_date_rec     = packed record
 2  1:u   1                          month : 0..12;
 2  1:u   1                          day :   0..31;
 2  1:u   1                          year :  0..99;
 2  1:u   1                        end;
 2  1:u   1      sc_info_type    = packed record
 2  1:u   1                          sc_version : string;
 2  1:u   1                          sc_date : sc_date_rec;
 2  1:u   1                          spec_char : sc_chset; (Characters not to echo)
 2  1:u   1                          misc_info : sc_misc_rec;
 2  1:u   1                        end;
 2  1:u   1      sc_long_string  = string[255];
 2  1:u   1      sc_scrn_command = (sc_whome, sc_eras_s, sc_erase_eol, sc_clear_lne,
 2  1:u   1                         sc_clear_scn, sc_up_cursor, sc_down_cursor,
 2  1:u   1                         sc_left_cursor, sc_right_cursor);
 2  1:u   1      sc_key_command  = (sc_backspace_key, sc_dc1_key, sc_eof_key, sc_etx_key,
 2  1:u   1                         sc_escape_key, sc_del_key, sc_up_key, sc_down_key,
 2  1:u   1                         sc_left_key, sc_right_key, sc_not_legal);
 2  1:u   1      sc_choice       = (sc_get, sc_give);
 2  1:u   1      sc_window       = packed array [0..0] of char;
 2  1:u   1      sc_tx_port      = record
 2  1:u   1                          row, col,              { screen relative}
 2  1:u   1                          height, width,         { size of txport (zero based)}
 2  1:u   1                          cur_x, cur_y  : integer;
 2  1:u   1                                   {cursor positions relative to the txport }
 2  1:u   1                        end;
 2  1:u   1
 2  1:u   1  procedure sc_use_info(do_what:sc_choice; var t_info:sc_info_type);
 2  1:u   1  procedure sc_use_port(do_what:sc_choice; var t_port:sc_tx_port);
 2  1:u   1  procedure sc_erase_to_eol(x,line:integer);
 2  1:u   1  procedure sc_left;
 2  1:u   1  procedure sc_right;
 2  1:u   1  procedure sc_up;
 2  1:u   1  procedure sc_down;
 2  1:u   1  procedure sc_getc_ch(var ch:char; return_on_match:sc_chset);
 2  1:u   1  procedure sc_clr_screen;
 2  1:u   1  procedure sc_clr_line (y:integer);
 2  1:u   1  procedure sc_home;
 2  1:u   1  procedure sc_eras_eos (x,line:integer);
 2  1:u   1  procedure sc_goto_xy(x, line:integer);
 2  1:u   1  procedure sc_clr_cur_line;
 2  1:u   1  function  sc_find_x:integer;
 2  1:u   1  function  sc_find_y:integer;
 2  1:u   1  function  sc_scrn_has(what:sc_scrn_command):boolean;
 2  1:u   1  function  sc_has_key(what:sc_key_command):boolean;
 2  1:u   1  function  sc_map_crt_command(var k_ch:char):sc_key_command;
 2  1:u   1  function  sc_prompt(line :sc_long_string; x_cursor,y_cursor,x_pos,
 2  1:u   1                 where:integer; return_on_match:sc_chset;
 2  1:u  21                 no_char_back:boolean; break_char:char):char;
 2  1:u   1  function sc_check_char(var buf:sc_window; var buf_index,bytes_left:integer)
 2  1:u   1                 :boolean;
 2  1:u   1  function space_wait(flush:boolean):boolean;
 2  1:u   1  procedure sc_init;
 2  1:u   1
 2  1:d   1      {$U screenops.code} screenops;
 2  1:d   1
 2  1:d   1   procedure display;
 2  2:d   1     var max,min:integer;
 2  2:d   3        i:integer;
 2  2:d   4        c:char;
 2  2:d   5        stat:array[0..29] of integer;
 2  2:d  35
 2  2:d  35     procedure pitch( x:integer);
```

Listing 3 continued on page 466

Listing 3 continued:

```
2  2:d   1          {------------------------------------------------}
2  2:d   1          { Printer dependent code to set line spacing.     }
2  2:d   1          { Arguments is in pixels. This version is for     }
2  2:d   1          { the MX70. Requires rewriting for other printers.}
2  2:d   1          {------------------------------------------------}
2  3:d   1          var b:packed array[0..2] of char;
2  3:0   0          begin
2  3:0   0          { common header for MX70 .. MX100 }
2  3:1   0          b[0]:=chr(27);
2  3:1   7          b[1]:='A';
2  3:1  15          b[2]:=chr(x);
2  3:1  22          unitwrite(6,b,3,,12);
2  3:1  30          {-------------------------}
2  3:1  30          { MX 80 version suffix    }
2  3:1  30          {   b[1]:='2';            }
2  3:1  30          {   unitwrite(6,b,2);     }
2  3:1  30          {-------------------------}
2  2:0   0          end;
2  2:0   0
2  2:0   0      {$N+}
2  2:d   1      function mean:integer;
2  4:d   1          var i,j:integer;
2  4:d   3              val:real;
2  4:0   0          begin
2  4:1   4          val:=0;
2  4:1   8          for i:=start to stop
2  4:1  11          do val:=val+stream^[i];
2  4:1  42          mean:=trunc(val/(stop-start));
2  2:0   0          end;
2  2:0   0
2  2:0   0  {--------------------------------------------------}
2  2:0   0  {                                                  }
2  2:0   0  {      VOICELAB PCM SPEECH ENEGERY PLOT            }
2  2:0   0  {                 PROCEDURE                        }
2  2:0   0  {                                                  }
2  2:0   0  {   (C)opyright John E. Hoot 1983. All rights      }
2  2:0   0  {      reserved                                    }
2  2:0   0  {                                                  }
2  2:0   0  {--------------------------------------------------}
2  2:d   1      procedure energy;
2  5:d   1          var delta,avg,val:integer;
2  5:d   4              cr,c:char;
2  5:d   6              i,j,last,next,lo,hi:integer;
2  5:d  12                  next_cross, last_cross, cross:integer;
2  5:d  15              print:boolean;
2  5:d  16              s:string;
2  5:d  57              f:text;
2  5:0   0          begin
2  5:1  13          sc_clr_screen;
2  5:1  15          repeat
2  5:2  15            c:=Sc_prompt(
2  5:2  16      'Energy (==) & Crossings (...) to: P)rinter:, D(isplay ',
2  5:2  21              -1,0,0,0,['P','D','p','d'],false,',');
2  5:2  40              writeln;
2  5:2  47              print:=false;
2  5:2  50              if (c='p') or (c='P') then
2  5:3  61                begin
2  5:4  61                rewrite(f,'printer:');
2  5:4  74                print:=true;
2  5:4  77                writeln(f);
2  5:4  83                writeln(f);
2  5:4  89                writeln(f);
2  5:4  95                writeln(f);
2  5:4 101                Writeln(f,'Energy: == ');
2  5:4 119                Writeln(f,'Zero Crossings: ...');
2  5:3 137                end;
2  5:1 137          until c in ['p','P','D','d'];
2  5:1 146          if print then pitch(4);
2  5:1 154          val:=0;
2  5:1 156          cross:=0;
2  5:1 159          {$R-}
2  5:1 159          s[0]:=chr(70);
2  5:1 165          {$R+}
2  5:1 165          next:=1;
2  5:1 167          next_cross:=1;
2  5:1 170          avg:=stream^[start]*100;
2  5:1 186          cr:=chr(13);
2  5:1 188          for i:=start to stop
2  5:1 191          do begin
2  5:3 207              delta:=avg div 100;
2  5:3 212              avg:=stream^[i]+avg-delta;
2  5:3 227              if delta<stream^[i] then
2  5:4 241                val:=val+(stream^[i]-delta)
2  5:3 254              else val:=val+(delta-stream^[i]);
2  5:3 273              if (stream^[i]-delta)*(stream^[i+1]-delta)<0 then
2  5:4 303                cross:=cross+1;
2  5:3 307              if (i-start) mod 50 = 49
2  5:3 318              then
2  5:4 325                begin
2  5:5 325                fillchar(s[1],70,' ');
2  5:5 335                last:=next;
2  5:5 338                next:=val div 75;
2  5:5 343                last_cross:=next_cross;;
2  5:5 346                if (next<=3) then next_cross:=0
2  5:5 351                else next_cross:=cross*2;
2  5:5 361                if next_cross=0 then next_cross:=1;
2  5:5 368                if last_cross>next_cross then
2  5:6 373                  begin
2  5:7 373                  lo:=next_cross;
2  5:7 375                  hi:=last_cross;
2  5:6 377                  end
2  5:5 377                else
2  5:6 379                  begin
2  5:7 379                  lo:=last_cross;
2  5:7 381                  hi:=next_cross;
2  5:6 383                  end;
2  5:5 383                fillchar(s[lo],hi-lo,'.');
2  5:5 394                s[next_cross]:='.';
2  5:5 401                if print then
2  5:6 404                  begin
2  5:7 404                  write(f,'          ');
2  5:7 416                  write(f,' ',copy(s,1,hi+1));
2  5:7 447                  unitwrite(6,cr,1,,12);
2  5:6 455                  end;
2  5:5 455                if print then fillchar(s[1],70,' ');
2  5:5 468                if next=0 then next:=1;
2  5:5 474                if next>55 then next:=55;
2  5:5 483                if last>next then
2  5:6 488                  begin
2  5:7 488                  lo:=next;
```

Listing 3 continued on page 467

Listing 3 continued:

```
2  5:7  480              hi:=last;
2  5:6  492              end
2  5:5  492           else
2  5:6  494              begin
2  5:7  494              lo:=last;
2  5:7  496              hi:=next;
2  5:6  498              end;
2  5:5  498           fillchar(s[lo],hi-lo,'=');
2  5:5  509           s[next]:='=';
2  5:5  516           if print then
2  5:6  519              begin
2  5:7  519              if (i mod 100)=99 then write(f,i-99:5)
2  5:7  542              else write(f,'     ');
2  5:7  556              writeln(f,' ',copy(s,1,hi+1));
2  5:6  593              end
2  5:5  593           else
2  5:6  595              writeln(i-99:5,' ',copy(s,1,55));
2  5:5  647           unitstatus(1,stat,1);
2  5:5  654           if stat[0]<>0 then
2  5:6  667              begin
2  5:7  667              read(keyboard,c);
2  5:7  675              if print then
2  5:8  678                 begin
2  5:9  678                 pitch(12);
2  5:9  681                 close(f);
2  5:9  688                 exit(energy);
2  5:8  693                 end
2  5:7  693              else exit(energy);
2  5:6  700              end;
2  5:5  700           val:=0;
2  5:5  702           cross:=0;
2  5:4  705           end;
2  5:2  705        end;
2  5:1  712        if print then
2  5:2  715        begin
2  5:3  715        pitch(12);
2  5:3  718        close(f);
2  5:2  725        end;
2  2:0    0     end;
2  2:0    0
2  2:0    0
2  2:d    1  procedure spectrum;
2  6:d    1     var t,i,j,w:integer;
2  6:d    5        e:real;
2  6:d    9        c:char;
2  6:d   10        print:boolean;
2  6:d   11        eg,f:array[0..8] of real;
2  6:d   83        bar:string[7];
2  6:d   87        pt:text;
2  6:0    0     begin
2  6:1   13     sc_clr_screen;
2  6:1   15     c:=sc_prompt('Plot Spectrum to: P)rinter:, D(isplay ',
2  6:1   21        -1,0,0,0,['D','d','p','P'],false,',');
2  6:1   41     writeln;
2  6:1   48     print:=false;
2  6:1   51     if (c='p') or (c='P') then
2  6:2   62        begin
2  6:3   62        rewrite(pt,'printer:');
2  6:3   75        print:=true;
2  6:3   78        writeln(pt);
2  6:3   84        writeln(pt);
2  6:3   90        writeln(pt);
2  6:3   96        writeln(pt);
2  6:2  102        end;
2  6:1  102     if print then writeln(pt) else writeln;
2  6:1  120     w:=20;
2  6:1  122     for i:=0 to 7
2  6:1  123     do begin
2  6:3  135        if print then write(pt,w:7) else write(w:7);
2  6:3  157        w:=w + w;
2  6:2  161        end;
2  6:1  166     if print then writeln(pt) else writeln;
2  6:1  184     for i:=0 to 8 do
2  6:2  197        begin
2  6:3  197        eg[i]:=0.0;
2  6:3  209        f[i]:=stream^[start];
2  6:2  231        end;
2  6:1  236     if print then
2  6:2  239        pitch(4);
2  6:1  242     for t:=start to stop
2  6:1  245     do begin
2  6:3  260        f[0]:=stream^[t];
2  6:3  280        w:=2;
2  6:3  282        for i:=1 to 8
2  6:3  283        do begin
2  6:5  295           f[i]:=f[i]-(f[i]-stream^[t])/w;
2  6:5  338           w:=w+w;
2  6:4  342           end;
2  6:3  347        for i:=0 to 7
2  6:3  348        do begin
2  6:5  360           e:=f[i]-f[i+1];
2  6:5  382           if e<0 then
2  6:6  389              eg[i]:=eg[i]-e
2  6:5  406           else eg[i]:=eg[i]+e;
2  6:4  433           end;
2  6:3  438        if (t-start) mod 100 = 99 then
2  6:4  456           begin
2  6:5  456           if print then write(pt,'  ')
2  6:5  471           else write('  ');
2  6:5  486           for i:=7 downto 0
2  6:5  487           do begin
2  6:7  500              bar:='       ';
2  6:7  508              w:=round(eg[i]/200);
2  6:7  523              j:=0;
2  6:7  525              c:='-';
2  6:7  529              while (j<w) and (j<8)
2  6:7  537              do begin
2  6:9  540                 bar[4+(j div 2)]:=c;
2  6:9  550                 bar[4-(j div 2)]:=c;
2  6:9  560                 if c='=' then c:='-' else c:='=';
2  6:9  575                 j:=j+1;
2  6:8  578                 end;
2  6:7  580              if print then write(pt,bar)
2  6:7  593              else write(bar);
2  6:7  606              eg[i]:=0.0;
2  6:7  618              unitstatus(1,stat,1);
2  6:7  625              if stat[0]>0 then
2  6:8  639                 begin
2  6:9  639                 read(keyboard,c);
2  6:9  648                 if print then
2  6:0  651                    begin
```

Listing 3 continued on page 468

Listing 3 continued:

```
2  6:1  651                pitch(12);
2  6:1  654                close(pt);
2  6:1  661                exit(spectrum);
2  6:0  666                end
2  6:9  666              else exit(spectrum);
2  6:8  673              end;
2  6:6  673          end;
2  6:5  679        if print then writeln(pt) else writeln;
2  6:4  687        end;
2  6:2  697      end;
2  6:1  703    if print then
2  6:2  706      begin
2  6:3  706      pitch(12);
2  6:3  709      close(pt);
2  6:2  716      end;
2  2:0    0    end;
2  2:0    0
2  2:d    1  procedure plot;
2  7:d    1    var max,bit,lo,hi,last,present,i,j,k:integer;
2  7:d   10        sp,c:char;
2  7:d   12        buf:packed array[0..400] of 0..255;
2  7:0    0    begin
2  7:1    4    sc_clr_screen;
2  7:1    6    repeat
2  7:2    6     sp:=sc_prompt(
2  7:2    7      'Plot Wave Form to: P(rinter, D(isplay, Q(uit ',
2  7:2   12       -1,0,0,0,
2  7:2   17       [' ','P','D','Q','p','d','q',' '],false,'?');
2  7:2   32      if sp=' ' then sc_clr_screen;
2  7:2   39      if (sp='D') or (sp='d') then
2  7:3   51        begin
2  7:4   51        writeln;
2  7:4   58        last:=stream^[start]  div 4;
2  7:4   73        for i:=start to stop
2  7:4   76        do begin
2  7:6   91          present:=stream^[i] div 4;
2  7:6  104          lo:=present; hi:=last;
2  7:6  108          if lo>hi then
2  7:7  113            begin
2  7:8  113            j:=hi;
2  7:8  115            hi:=lo;
2  7:8  117            lo:=j;
2  7:7  119            end;
2  7:6  119          for j:=0 to lo do write(' ');
2  7:6  147          for j:=lo to hi
2  7:6  148          do write('-');
2  7:6  175          writeln;
2  7:6  182          last:=present;
2  7:6  184          unitstatus(1,stat,1);
2  7:6  191          if stat[0]<>0 then
2  7:7  204            begin
2  7:8  204            read(keyboard,c);
2  7:8  213            exit(plot);
2  7:7  218            end;
2  7:5  218          end;
2  7:3  224        end;
2  7:2  224      if (sp='P') or (sp='p') then
2  7:3  236        begin
2  7:4  236        fillchar(buf,4,13);
2  7:4  243        unitwrite(6,buf,4);
2  7:4  252        pitch(8);
2  7:4  255        last:=(stream^[start] * 3) div 2;
2  7:4  272        for i:=start to stop
2  7:4  275        do begin
2  7:6  290          bit:=128;
2  7:6  293          fillchar(buf,400,0);
2  7:6  302          max:=0;
2  7:6  305          for k:=0 to 7
2  7:6  306          do begin
2  7:8  316            present:=(stream^[i+k] * 3) div 2;
2  7:8  335            lo:=present;
2  7:8  337            hi:=last;
2  7:8  339            if lo>hi then
2  7:9  344              begin
2  7:0  344              j:=hi;
2  7:0  346              hi:=lo;
2  7:0  348              lo:=j;
2  7:9  350              end;
2  7:8  350            if hi>max then max:=hi;
2  7:8  358            for j:=lo to hi
2  7:8  359            do buf[4+j]:=buf[4+j]+bit;
2  7:8  404            last:=present;
2  7:8  406            bit:=bit div 2;
2  7:7  410            end;
2  7:6  415          i:=i+7;
2  7:6  419          max:=max+1;
2  7:6  423          {------------------------------}
2  7:6  423          { Start of MX70's escape to    }
2  7:6  423          { graphics sequence            }
2  7:6  423          {------------------------------}
2  7:6  423          buf[0]:=27;
2  7:6  437          buf[1]:=ord('K');
2  7:6  452          buf[2]:=(max mod 256);
2  7:6  474          buf[3]:=(max  div 256);
2  7:6  492          {------------------------------}
2  7:6  492          { End of MX70's escape to      }
2  7:6  492          { graphics sequence            }
2  7:6  492          {------------------------------}
2  7:6  492          unitwrite(6,buf,max+4,,12);
2  7:6  503          buf[0]:=13;
2  7:6  517          unitwrite(6,buf,1);
2  7:6  526          unitstatus(1,stat,1);
2  7:6  533          if stat[0]<>0 then
2  7:7  546            begin
2  7:8  546            read(keyboard,c);
2  7:8  555            pitch(12);
2  7:8  558            exit(plot);
2  7:7  563            end;
2  7:5  563          end;
2  7:4  569        pitch(12);
2  7:3  572        end;
2  7:1  572    until (sp='q') or (sp='Q');
2  2:0    0    end;
2  2:0    0    {$N-}
2  2:0    0
2  2:0    0  begin
2  2:1    0  sc_clr_screen;
2  2:1    2  repeat
```

Listing 3 continued on page 469

Listing 3 continued:

```
2   2:2    2          c:=sc_prompt(
2   2:2    3             concat( 'Stats: E(nergy & Crosses, P(lot,',
2   2:2   19             ' A)vg, M)ax&min, S)pect, Q)uit '),
2   2:2   31              -1,0,0,0,['p','e','a','m','s','q','P','E','A','M','S','Q',' '],
2   2:2   44              FALSE,',');
2   2:2   50          case c of
2   2:2   54            ' ':sc_clr_screen;
2   2:2   59            'A','a':begin
2   2:4   59                    writeln;
2   2:4   66                    writeln('Computing....');
2   2:4   86                    write('Mean value from ',start,' to ',stop,
2   2:4  134                           ' is ',mean);
2   2:3  158                    end;
2   2:2  161            'M','m':begin
2   2:4  161                    writeln;
2   2:4  168                    sc_clr_cur_line;
2   2:4  170                    writeln('Computing....');
2   2:4  190                    max:=0;
2   2:4  192                    min:=255;
2   2:4  195                    for i:=start to stop-1
2   2:4  201                    do begin
2   2:6  211                       if stream^[i]>max then max:=stream^[i];
2   2:6  236                       if stream^[i]<min then min:=stream^[i];
2   2:5  261                       end;
2   2:4  266                    writeln;
2   2:4  273                    writeln('Max from ',start,' to ',stop,' is ',
2   2:4  334                          max,'.');
2   2:4  360                    writeln('Min from ',start,' to ',stop,' is ',
2   2:4  421                          min,'.');
2   2:3  447                    end;
2   2:2  449            'E','e':Energy;
2   2:2  453            'P','p':plot;
2   2:2  457            'S','s':Spectrum;
2   2:2  461            end;
2   2:1  464      until (c='Q') or (c='q');
2   1:0    0      end;
2   1:0    0      end (voice_dsp).

End of Compilation.
```

```
S(et Tempo     39
B(eginning      0
E(nd            0
R(ecord
P(lay
Q(uit
```

Figure 6: *Menu screen for the Record and Listen routine.*

Text continued from page 457:

Upon your selecting the Energy and Crosses plot, the program asks whether the plot is to be routed to the printer or to the video display. Once a selection is made, the program begins to produce graphs like those in figure 4 in Part 1 of this article (July, pages 202 and 203), which are graphs of the spectral energy and number of zero-crossings contained in the signal. You can abort the plot before it reaches the End index in the speech by pressing any character on the keyboard.

When you select Plot, the program asks whether the plot is to be routed to the printer or to the display. Once a selection is made, the program begins to print or display graphs like those in figure 3 from last month (page 198). This plot, too, can be stopped by pressing any character on the keyboard.

The statistics menu also contains functions to compute three useful scalar values: the maximum waveform peak, the minimum waveform peak, and the average (DC—direct current) bias of the speech-buffer segment. These values are useful primarily in calibrating the input signal level. The optimal signal parameters for a properly calibrated amplifier for voiced input speech are:

Maximum Signal	254
Minimum Signal	1
Average Value	127

You'll rarely attain these values exactly, but grossly underdriving the A/D converter or setting excessive DC-offset values can badly distort digital speech's intelligibility and introduce errors into Voice Lab's analysis computations.

When you select the Spectrum option, the program gives you the choice of routing output to the printer or to the display. Once you've made your selection, the program begins to produce graphs like those in figure 5 in part 1 (pp. 202 and 203). As above, this plot can be stopped by pressing any character on the keyboard.

Both the spectrum-analysis and the waveform plots take some time to generate. So that the program may run as fast a possible, the code in the Voice Display unit has native-code directives bracketing these sections. In some implementations of the UCSD p-System, such as the one for the IBM Personal Computer, it is possible to send the program's p-code (pseudocode) object file through a native-code generator. This will translate the indicated section of the program to machine instructions directly executable by the microprocessor. As a result, the computation time in this section will be dramatically reduced, while other, noncritical sections of the program are left in the more compact p-code representation. Just remember that producing native code for the Voice Display unit will render its object code incompatible with p-Systems running on different processors.

Messages Menu

The Messages menu contains just these choices:

Messages:
L(iteral
F(ile
Q(uit

It allows you to have the word-list-based speech-synthesis functions in Voice Lab read back to you files or strings that you have keyed in. If you select Literal input, the program begins prompting you for input lines. After the line has been entered, it is passed to the speech synthesizer in the Voice Message unit (*listing 4*). It will continue prompting for additional lines until a blank line is entered. If you use the File option, specifying the name of an existing file, the program reads the file one line at a time and passes the text in it to the speech synthesizer.

```
Digital Filter: term <0..5>, D)c offset, F)ilter, Q)uit

    Formula X[T] =
      0.50 * x[t] + 0.50 * x[t + 1] + 5

                            Term     Delay     Weight
                             0)       0t        0.50
                             1)       1t        0.50
                             2)       0t        0.00
                             3)       0t        0.00
                             4)       0t        0.00
                             5)       0t        0.00
                            D)c Offset: 5
```

Figure 7: *Sample screen display produced by the filter routine.*

```
Formula Coefficients: W(eight, D(elay, Q(uit

    Formula X[T] =
      0.50 * x[t] + 0.50 * x[t - 1]

                            Term     Delay     Weight
                             0)       0t        0.50
                      ---> 1)       1t        0.50
                             2)       0t        0.00
                             3)       0t        0.00
                             4)       0t        0.00
                             5)       0t        0.00
                            D)c Offset: 0
```

Figure 8: *Sample coefficient-modifying screen in the filter routine.*

Filter Menu

When the digital-filter option is selected, a screen similar to that in figure 7 is displayed. This screen displays the options available across the top line, along with the current difference equation and a table of terms. If the formula indicates the operation you wish to perform, press "F" to begin filtering. The program will make one pass through the speech buffer, from beginning to end, applying the indicated formula. The message:

Computing . . . .

will be displayed across the bottom of the display. For each 50 samples processed another period is displayed so you can watch the progress.

This operation, like the plots, can take a long time, particularly if you have specified a very complex polynomial. Like the plotting unit, the Voice Filter unit (listing 5) contains the compiler directives that will allow you to generate native code to perform the computation and improve the system's performance.

To modify the difference equation used in filtering the contents of the speech buffer, type the number corresponding to the equation term you wish to edit. When you do this, the screen will change to appear as shown in figure 8. You can modify both the weight and delay values in the equation. The DC-offset value can be changed only from the primary edit screen. When the selected term has been set to your satisfaction, you can return to the primary filter screen by selecting Quit. This process can be repeated indefinitely until all the terms of the equation have been set.

Multistage filtering can be achieved by repeatedly filtering the same speech-buffer segment. Recursive or closed-loop filters (those with feedback and oscillators) can be simulated by using negative delay values. When using a recursive filter, take care to make sure it is stable.

Text continued on page 475

a message to our subscribers

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03458

Listing 4: *The Voice Messages (Voice_msg) unit, which converts text represented by ASCII characters into audible speech.*

```
Pascal Compiler IV.1 c5s-4      3/27/83

 2   1:d    1  Unit Voice_msg;
 2   1:d    1
 2   1:d    1  Interface
 2   1:d    1  {--------------------------------------------}
 2   1:d    1  {                                            }
 2   1:d    1  {       VOICELAB TEXT-TO-SPEECH OUTPUT       }
 2   1:d    1  {              SERVICE UNIT                  }
 2   1:d    1  {                                            }
 2   1:d    1  {  (C)opyright John E. Hoot 1983. All rights }
 2   1:d    1  {      reserved                              }
 2   1:d    1  {                                            }
 2   1:d    1  {--------------------------------------------}
 2   1:d    1
 2   1:d    1      function speakword( s:string ): boolean;
 2   1:d    1      procedure speakline( ln:string );
 2   1:d    1
 2   1:d    1  Implementation
 2   1:d

               Using ANALOGIO
 2   1:u
 2   1:u       {--------------------------------------------}
 2   1:u       {                                            }
 2   1:u       {       VOICELAB ANALOG INPUT/OUTPUT         }
 2   1:u       {              SERVICE UNIT                  }
 2   1:u       {                                            }
 2   1:u       {  (C)opyright John E. Hoot 1983. All rights }
 2   1:u       {      reserved                              }
 2   1:u       {                                            }
 2   1:u       {--------------------------------------------}
 2   1:u
 2   1:u         const vox_buflen = 16383;
 2   1:u    1
 2   1:u    1    type vox_bufrange = 0..vox_buflen;
 2   1:u    1         byte = 0..255;
 2   1:u    1         vox_buffer=packed array[vox_bufrange] of byte;
 2   1:u    1         vox_ptr = ^vox_buffer;
 2   1:u    1
 2   1:u    1    var tempo,start,stop:vox_bufrange;
 2   1:u    4        stream:vox_ptr;
 2   1:u    5
 2   1:u    5    procedure ADC( var ptr:vox_buffer;
 2   1:u    2                   offset, len: vox_bufrange; rate:integer );
 2   1:u    1
 2   1:u    1    procedure DAC( var ptr:vox_buffer;
 2   1:u                      offset, len:vox_bufrange; rate:integer );
 2   1:u    1
 2   1:d    1    uses {$U analog.io.code} analog_io,

               Using VOICEDIC
 2   1:u
 2   1:u       {--------------------------------------------}
 2   1:u       {                                            }
 2   1:u       {      VOICELAB VOCABULARY DICTIONARY        }
 2   1:u       {             MANAGEMENT UNIT                }
 2   1:u       {                                            }
 2   1:u       {  (C)opyright John E. Hoot 1983. All rights }
 2   1:u       {      reserved                              }
 2   1:u       {                                            }
 2   1:u       {--------------------------------------------}
 2   1:u
 2   1:u         type dict_result=(successful,buf_oflow, not_found,
 2   1:u    1                      dict_full,dup_entry,index_oflow);
 2   1:u    1
 2   1:u    1    function find_word( name:string; var idx:integer ): boolean;
 2   1:u    1
 2   1:u    1    function index_word( idx:integer; var name:string;
 2   1:u                             var ln:integer  ) : boolean;
 2   1:u    1
 2   1:u    1    function insert_words( s:string ) : dict_result;
 2   1:u    1
 2   1:u    1    function append_word( name:string ) :  dict_result;
 2   1:u    1
 2   1:u    1    function remove_word( name:string ) : dict_result;
 2   1:u    1
 2   1:u    1    procedure clear_dictionary;
 2   1:u    1
 2   1:d    1       {$U voice.dict.code} voice_dictionary;
 2   1:d
 2   1:d         var
 2   1:d            result: dict_result;
 2   1:d            dummy:integer;
 2   1:d            s:string;
 2   1:d    1       c:char;
 2   1:d    2
 2   1:d    2   function speakword( s:string ): boolean);
 2   2:d    1      var i:integer;
 2   2:0    0      begin
 2   2:1    5      start:=0;
 2   2:1   14      stop:=0;
 2   2:1   23      result:=append_word(s);
 2   2:1   30      if result=successful then
 2   2:2   34         begin
 2   2:3   34         speakword:=true;
 2   2:3   37         dac(stream^,start,stop,tempo);
 2   2:2   61         end
 2   2:1   61      else speakword:=false;
 2   1:0    0      end;
 2   1:0    0
 2   1:d    1   procedure speakline( ln:string );
 2   3:d    1     var i,j,k:integer;
 2   3:d    4        name:string[7];
 2   3:d    8        word:string[8];
 2   3:d   13     {$R-}
 2   3:0    0     begin
 2   3:1    8     for i:=1 to length(ln)
 2   3:1   14     do if (ln[i]<='z') and (ln[i]>='a') then
 2   3:3   41          ln[i]:=chr(ord(ln[i])-32);
 2   3:1   58     i:=1;
 2   3:1   61     while i<= length(ln)
 2   3:1   67     do begin
 2   3:3   71        j:=0;
 2   3:3   73        while (length(ln)>=i) and (ln[i]=' ')
 2   3:3   88        do i:=i+1;
```

Listing 4 continued on page 472

Listing 4 continued:

```
2   3:3   96        while (length(ln)>=i) and (ln[i] >='A')
2   3:3  111              and (ln[i]<='Z')
2   3:3  120        do begin
2   3:5  123           i:=i+1;
2   3:5  126           j:=j+1;
2   3:4  129           end;
2   3:3  131        if j>7 then
2   3:4  136           begin
2   3:5  136           if not speakword(copy(ln,i-j,7)) then
2   3:6  156              for k:=j downto 1
2   3:6  157              do if not speakword(copy(ln,i-k,1)) then
2   3:8  187                 writeln(copy(ln,i-k,1),' ?');
2   3:4  235           end
2   3:3  235        else
2   3:4  237           begin
2   3:5  237           if not speakword(copy(ln,i-j,j)) then
2   3:6  257              for k:=j downto 1
2   3:6  258              do if not speakword(copy(ln,i-k,1)) then
2   3:8  288                 writeln(copy(ln,i-k,1),' ?');
2   3:4  336           end;
2   3:3  336        while (length(ln)>=i) and (ln[i] >='0') and
2   3:3  352              (ln[i]<='9')
2   3:3  360        do begin
2   3:5  364           case ln[i] of
2   3:5  371              '0': word:='ZERO';
2   3:5  380              '1': word:='ONE';
2   3:5  389              '2': word:='TO';
2   3:5  398              '3': word:='THREE';
2   3:5  407              '4': word:='FOR';
2   3:5  416              '5': word:='FIVE';
2   3:5  425              '6': word:='SIX';
2   3:5  434              '7': word:='SEVEN';
2   3:5  443              '8': word:='ATE';
2   3:5  452              '9': word:='NINE';
2   3:5  461           end;
2   3:5  464           if not speakword(word) then
2   3:6  471              writeln(ln[i],' ?');
2   3:5  504           i:=i+1;
2   3:4  507           end;
2   3:3  510        while (length(ln)>=i) and
2   3:3  517           (not (((ln[i]<='9') and (ln[i]>='0')) or
2   3:3  534                 ((ln[i]<='Z') and (ln[i]>='A'))))
2   3:3  553        do begin
2   3:5  556           if not speakword(copy(ln,i,1)) then ;
2   3:5  574           i:=i+1;
2   3:4  577           end;
2   3:2  579        end;
2   1:0    0     end;
2   1:0    0     {$R+}
2    :0    0  end {voice_messages}.

End of Compilation.
```

Listing 5: *The Voice Filtering unit (Voice_filter), which can perform many kinds of digital filtration on the contents of the speech buffer.*

```
Pascal Compiler IV.1 c5s-4      3/27/83

2   1:d   1  Unit Voice_filter;
2   1:d   1
2   1:d   1  Interface
2   1:d   1  {-------------------------------------------}
2   1:d   1  {                                           }
2   1:d   1  {   VOICELAB PCM SPEECH RECURSIVE DIGITAL   }
2   1:d   1  {              FILTERING UNIT               }
2   1:d   1  {                                           }
2   1:d   1  {  (C)opyright John E. Hoot 1983. All rights }
2   1:d   1  {     reserved                              }
2   1:d   1  {                                           }
2   1:d   1  {-------------------------------------------}
2   1:d   1
2   1:d   1     procedure filter;
2   1:d   1
2   1:d   1  implementation
2   1:d   1

             Using ANALOGIO

2   1:u   1
2   1:u   1  {-------------------------------------------}
2   1:u   1  {                                           }
2   1:u   1  {       VOICELAB ANALOG INPUT/OUTPUT        }
2   1:u   1  {              SERVICE UNIT                 }
2   1:u   1  {                                           }
2   1:u   1  {  (C)opyright John E. Hoot 1983. All rights }
2   1:u   1  {     reserved                              }
2   1:u   1  {                                           }
2   1:u   1  {-------------------------------------------}
2   1:u   1
2   1:u   1    const vox_buflen = 16383;
2   1:u   1
2   1:u   1    type vox_bufrange = 0..vox_buflen;
2   1:u   1         byte = 0..255;
2   1:u   1         vox_buffer=packed array[vox_bufrange] of byte;
2   1:u   1         vox_ptr = ^vox_buffer;
2   1:u   1
2   1:u   1    var tempo,start,stop:vox_bufrange;
2   1:u   4        stream:vox_ptr;
2   1:u   5
2   1:u   5    procedure ADC( var ptr:vox_buffer;
2   1:u   2                   offset, len: vox_bufrange; rate:integer );
2   1:u   1
2   1:u   1    procedure DAC( var ptr:vox_buffer;
2   1:u                       offset, len:vox_bufrange; rate:integer );
2   1:u   1
2   1:d   1  uses {$U analog.io.code} analog_io,

             Using SCREENOP

2   1:u   1
2   1:u   1  const
2   1:u   1     sc_fill_len = 11;
```

Listing 5 continued on page 473

Listing 5 continued:

```
2   1:u   1         sc_eol = 13;
2   1:u   1
2   1:u   1   type
2   1:u   1         sc_chset       = set of char;
2   1:u   1         sc_misc_rec    = packed record
2   1:u   1                            height, width : 0..255;
2   1:u   1                            can_break, slow, xy_crt, lc_crt,
2   1:u   1                            can_upscroll, can_downscroll : boolean;
2   1:u   1                          end;
2   1:u   1         sc_date_rec    = packed record
2   1:u   1                            month : 0..12;
2   1:u   1                            day :   0..31;
2   1:u   1                            year :  0..99;
2   1:u   1                          end;
2   1:u   1         sc_info_type   = packed record
2   1:u   1                            sc_version : string;
2   1:u   1                            sc_date : sc_date_rec;
2   1:u   1                            spec_char : sc_chset; {Characters not to echo}
2   1:u   1                            misc_info : sc_misc_rec;
2   1:u   1                          end;
2   1:u   1         sc_long_string = string[255];
2   1:u   1         sc_scrn_command = (sc_whome, sc_eras_s, sc_erase_eol, sc_clear_lne,
2   1:u   1                           sc_clear_scn, sc_up_cursor, sc_down_cursor,
2   1:u   1                           sc_left_cursor, sc_right_cursor);
2   1:u   1         sc_key_command  = (sc_backspace_key, sc_dc1_key, sc_eof_key, sc_etx_key,
2   1:u   1                           sc_escape_key, sc_del_key, sc_up_key, sc_down_key,
2   1:u   1                           sc_left_key, sc_right_key, sc_not_legal);
2   1:u   1         sc_choice      = (sc_get, sc_give);
2   1:u   1         sc_window      = packed array [0..0] of char;
2   1:u   1         sc_tx_port     = record
2   1:u   1                            row, col,             { screen relative}
2   1:u   1                            height, width,        { size of txport (zero based)}
2   1:u   1                            cur_x, cur_y  : integer;
2   1:u   1                                   {cursor positions relative to the txport }
2   1:u   1                          end;
2   1:u   1
2   1:u   1       procedure sc_use_info(do_what:sc_choice; var t_info:sc_info_type);
2   1:u   1       procedure sc_use_port(do_what:sc_choice; var t_port:sc_tx_port);
2   1:u   1       procedure sc_erase_to_eol(x,line:integer);
2   1:u   1       procedure sc_left;
2   1:u   1       procedure sc_right;
2   1:u   1       procedure sc_up;
2   1:u   1       procedure sc_down;
2   1:u   1       procedure sc_getc_ch(var ch:char; return_on_match:sc_chset);
2   1:u   1       procedure sc_clr_screen;
2   1:u   1       procedure sc_clr_line (y:integer);
2   1:u   1       procedure sc_home;
2   1:u   1       procedure sc_eras_eos (x,line:integer);
2   1:u   1       procedure sc_goto_xy(x, line:integer);
2   1:u   1       procedure sc_clr_cur_line;
2   1:u   1       function  sc_find_x:integer;
2   1:u   1       function  sc_find_y:integer;
2   1:u   1       function  sc_scrn_has(what:sc_scrn_command):boolean;
2   1:u   1       function  sc_has_key(what:sc_key_command):boolean;
2   1:u   1       function  sc_map_crt_command(var k_ch:char):sc_key_command;
2   1:u   1       function  sc_prompt(line :sc_long_string; x_cursor,y_cursor,x_pos,
2   1:u   1                       where:integer; return_on_match:sc_chset;
2   1:u  21                           no_char_back:boolean; break_char:char):char;
2   1:u   1       function sc_check_char(var buf:sc_window; var buf_index,bytes_left:integer)
2   1:u                                  :boolean;
2   1:u   1       function space_wait(flush:boolean):boolean;
2   1:u   1       procedure sc_init;
2   1:u   1
2   1:d   1          {$U screenops.code} screen_ops;
2   1:d   1
2   1:d   1     const lastline = 23;
2   1:d   1
2   1:d   1     type equation =
2   1:d   1        record
2   1:d   1          term:array[0..5] of
2   1:d   1            record
2   1:d   1              delay: integer;
2   1:d   1              weight: real;
2   1:d   1              signal: real;
2   1:d   1            end;
2   1:d   1          dc_offset:integer;
2   1:d   1        end;
2   1:d   1
2   1:d   1     var i:integer;
2   1:d   2         formula:equation;
2   1:d  57
2   1:d  57     procedure filter;
2   2:d   1        var i,j:integer;
2   2:d   3            c:char;
2   2:d   4            term_tot:real;
2   2:d   8
2   2:d   8        procedure scheme;
2   3:d   1           var first_term:boolean;
2   3:0   0           begin
2   3:1   0           sc_clr_line(5);
2   3:1   3           writeln('Formula: X[T] = ');
2   3:1  23           write('   ');
2   3:1  36           first_term:=true;
2   3:1  38           for i:=0 to 5
2   3:1  39           do with formula.term[i]
2   3:2  59              do if weight<>0 then
2   3:4  69                 begin
2   3:5  69                 if (not first_term) and (weight>0)
2   3:5  79                 then write('+');
2   3:5  92                 write(weight:5:2,' * x[t');
2   3:5 118                 if delay>0 then write('-',delay);
2   3:5 144                 write('] ');
2   3:5 157                 first_term:=false;
2   3:4 159                 end;
2   3:1 167           if formula.dc_offset>0 then
2   3:2 175              write('+ ',formula.dc_offset );
2   3:1 200           if formula.dc_offset<0 then
2   3:2 208              write('- ',-formula.dc_offset);
2   3:1 234           writeln;
2   2:0   0           end;
2   2:0   0
2   2:0   0
2   2:d   1        procedure terms( idx:integer);
2   4:d   1           var c:char;
2   4:0   0           begin
2   4:1   0           repeat
```

Listing 5 continued on page 474

Listing 5 continued:

```
2   4:2    0          c:=sc_prompt(
2   4:2    1            'Formula Coefficients: W(eight, D(elay, Q(uit',
2   4:2    6            15,10+idx,0,0,['w','d','q','W','Q','D'],false,'?');
2   4:2   26          write('—>');
2   4:2   39          case c of
2   4:2   43            'W','w':
2   4:3   43              begin
2   4:4   43              gotoxy(36,10+idx);
2   4:4   50              write(' ':9);
2   4:4   60              gotoxy(36,10+idx);
2   4:4   67              readln(formula.term[idx].weight);
2   4:4   81              gotoxy(35,10+idx);
2   4:4   96              write(formula.term[idx].weight:10:2);
2   4:4  118              scheme;
2   4:3  120              end;
2   4:2  122            'D','d':
2   4:3  122              with formula.term[idx]
2   4:3  130              do begin
2   4:5  131                gotoxy(26,idx+10);
2   4:5  137                write(' ':8);
2   4:5  147                gotoxy(26,idx+10);
2   4:5  153                readln(delay);
2   4:5  168                gotoxy(25,10+idx);
2   4:5  174                write(delay:9);
2   4:5  184                scheme;
2   4:4  186                end;
2   4:2  188            end;
2   4:1  191          until (c='Q') or (c='q');
2   4:1  203        gotoxy(15,10+idx);
2   4:1  209        write('   ');
2   4:1  222        sc_clr_line(0);
2   2:0    0        end;
2   2:0    0
2   2:0    0      {$N+}
2   2:0    0      begin
2   2:1    4      sc_clr_screen;
2   2:1    6      gotoxy(15,8);
2   2:1   10      write('Term':10,'Delay':10,'Weight':10);
2   2:1   49      for i:=0 to 5
2   2:1   50      do with formula.term[i]
2   2:2   66        do begin
2   2:4   68          gotoxy(15,10+i);
2   2:4   74          write(i:9,')',delay:9,'t',weight:10:2 );
2   2:3  126          end;
2   2:1  131      gotoxy(15,17);
2   2:1  135      write('DC Offset: ',formula.dc_offset );
2   2:1  160      scheme;
2   2:1  162      repeat
2   2:2  162        c:=sc_prompt(concat('Digital Filter: term <0..5>,',
2   2:2  176              ' D)c offset, F(ilter, Q(uit ')
2   2:2  187              ,-1,0,0,0,
2   2:2  193              ['0'..'5','d','D','F','f','Q','q'],false,'?');
2   2:2  207        if (c<='5') and (c>='0') then
2   2:3  218          terms( ord(c)-ord('0') )
2   2:2  222        else
2   2:3  227          case c of
2   2:3  231          'D','d':
2   2:4  231            begin
2   2:5  231            gotoxy(26,17);
2   2:5  235            write(' ':10);
2   2:5  245            gotoxy(26,17);
2   2:5  249            readln(formula.dc_offset);
2   2:5  267            gotoxy(26,17);
2   2:5  271            write(formula.dc_offset);
2   2:5  283            write('                          ');
2   2:5  296            scheme;
2   2:4  298            end;
2   2:3  301        'F','f':
2   2:4  301            begin
2   2:5  301            for j:=0 to 5
2   2:5  302            do with formula.term[j]
2   2:6  318              do signal:=stream^[start];
2   2:5  342            gotoxy(0,lastline-3);
2   2:5  348            write('Computing.');
2   2:5  361            for i:=start to stop
2   2:5  364            do begin
2   2:7  375              if ((start-i) mod 100) = 0 then write('.');
2   2:7  400              term_tot:=0;
2   2:7  404              for j:=0 to 5
2   2:7  405              do with formula.term[j]
2   2:8  422                do if weight<>0.0 then
2   2:0  434                    begin
2   2:1  434                    signal:=(stream^[i]-signal)/(delay+1)
2   2:1  456                       +signal;
2   2:1  464                       term_tot:=term_tot+weight*signal;
2   2:0  478                    end;
2   2:7  483              term_tot:=term_tot+formula.dc_offset;
2   2:7  493              if term_tot>255.0 then stream^[i]:=255
2   2:7  510              else if term_tot<0 then stream^[i]:=0
2   2:8  535                 else stream^[i]:=round(term_tot);
2   2:6  560              end;
2   2:5  566            sc_clr_line(lastline-3);
2   2:5  571            sc_clr_line(lastline-2);
2   2:5  576            sc_clr_line(lastline-1);
2   2:4  580            end;
2   2:3  582          end;
2   2:1  585      until (c='Q') or (c='q');
2   2:1  597      sc_clr_screen;
2   1:0    0      end;{filter}
2   1:0    0  {$N-}
2   1:0    0
2   1:0    0  begin
2   1:1    0  for i:=0 to 5
2   1:1    1  do with formula.term[i]
2   1:2   20    do begin
2   1:4   22      weight:=0.0;
2   1:4   30      delay:=0;
2   1:3   34      end;
2   1:1   40  formula.dc_offset:=0;
2   1:1   46  formula.term[0].weight:=1.0;
2   1:1   60  ***;
2    :0    0  end {voice_filter}.
```

End of Compilation.

Listing 6: *The Analog-I/O unit (Analog_IO), a hardware-specific unit that reads data from the analog-to-digital converter and writes data to the digital-to-analog converter.*

```
Pascal Compiler IV.1 c5s-4      3/27/83

 2   1:d    1  UNIT ANALOG_IO;
 2   1:d    1
 2   1:d    1  Interface
 2   1:d    1  {-----------------------------------------------}
 2   1:d    1  {                                               }
 2   1:d    1  {           VOICELAB ANALOG INPUT/OUTPUT        }
 2   1:d    1  {                  SERVICE UNIT                 }
 2   1:d    1  {                                               }
 2   1:d    1  {   (C)opyright John E. Hoot 1983. All rights   }
 2   1:d    1  {       reserved                                }
 2   1:d    1  {                                               }
 2   1:d    1  {-----------------------------------------------}
 2   1:d    1
 2   1:d    1     const vox_buflen = 16383;
 2   1:d    1
 2   1:d    1     type vox_bufrange = 0..vox_buflen;
 2   1:d    1          byte = 0..255;
 2   1:d    1          vox_buffer=packed array[vox_bufrange] of byte;
 2   1:d    1          vox_ptr = ^vox_buffer;
 2   1:d    1
 2   1:d    1     var tempo,start,stop:vox_bufrange;
 2   1:d    4         stream:vox_ptr;
 2   1:d    5
 2   1:d    5     procedure ADC( var ptr:vox_buffer;
 2   1:d    2                    offset, len: vox_bufrange; rate:integer );
 2   1:d    1
 2   1:d    1     procedure DAC( var ptr:vox_buffer;
 2   1:d    1                    offset, len:vox_bufrange; rate:integer );
 2   1:d    1
 2   1:d    1  Implementation
 2   1:d    1
 2   1:d    1
 2   1:d    1     procedure sample( var ptr:vox_buffer; offset, len: vox_bufrange );
 2   1:d    1     external;
 2   1:d    1
 2   1:d    1     procedure play( var ptr:vox_buffer; offset, len, rate:vox_bufrange);
 2   1:d    1     external;
 2   1:d    1
 2   1:d    1     procedure ADC;
 2   2:0    0       begin
 2   2:1    0       sample( ptr,offset,len  );
 2   1:0    0       end;
 2   1:0    0
 2   1:d    1     procedure DAC;
 2   3:0    0       begin
 2   3:1    0       play( ptr, offset, len, rate );
 2   1:0    0       end;
 2   1:0    0
 2   1:0    0       begin
 2   1:1    0       new(stream);
 2   1:1    7       start:=0;
 2   1:1   15       stop:=0;
 2   1:1   23       tempo:=39;
 2   1:1   32       ***;
 2   1:1   34       dispose(stream);
 2    :0    0       end.
```

Text continued from page 470:

Installation and Adaptation

The Voice Lab program and units were developed in UCSD Pascal under version IV of the p-System (distributed by Softech Microsystems) and operate most effectively under that version of the system. Voice Lab relies strongly on the p-System's modular unit philosophy, so adapting Voice Lab to another operating environment would not be a simple task.

To get Voice Lab to run under Apple Pascal version 1.1, you must relink the units after each modification, which makes for slow work. Additionally, the virtual-memory management under the version IV p-System allows Voice Lab to operate with a larger speech buffer on an Apple than does Apple Pascal 1.1.

Voice Lab is designed to be portable to various computers in both source and object code. With two exceptions, the object code for the main program and all the units can be moved from machine to machine without recompilation. I have successfully transported Voice Lab between the IBM Personal Computer and the Apple II. The two exceptions to portability are the printer-output routine and the Analog I/O unit.

The Analog I/O unit (listing 6) performs the actual digitizing of the speech input and synthesis of the speech output. The specific characteristics of the hardware interface to the D/A and A/D converters will inevitably differ from machine to machine. To accommodate this situation, the Analog I/O unit is structured to require that two assembly-language procedures, Sample and Play, be linked into it.

The Sample procedure reads the computer's analog input at a rate determined by one of its calling arguments. Each sample is assumed to be an 8-bit unsigned number in the range 0 through 255, and the quiescent value of the input should be 127 or 128. The samples should be written to memory beginning at the location indicated by the sum of two other arguments shown in listing 6, the Offset and the Ptr base address. Sampling should continue until the number of samples specified by the Len argument have been accumulated. At that time, the Sample procedure should return control to Analog I/O.

The Play procedure performs the inverse operation to Sample. All arguments to Play are interpreted in the same fashion as Sample, except values are read from memory and written to the D/A converter.

The only other area of Voice Lab that may require modification is the printer-output section in the Voice Display unit. The Voice Display unit, as shown in listing 3, is designed to operate with an Epson MX-70 printer. The lines of source code specific to the MX-70 are demarcated by comments; these will have to be rewritten if you have a different printer.

The waveform-routine is designed to operate with dot-matrix graphics. If your computer does not support dot-matrix graphical output, you can

use hyphens or microspaced periods to generate the graphical output, but producing the output will take a long time. If hyphens are used, the same algorithm that is used on the display can be applied to the printer.

These modifications should not be hard, as such things go, so after just a little time modifying the print routines and adapting to your D/A and A/D hardware, you should be ready to begin investigating digital speech synthesis and analysis with Voice Lab.

Conclusions

Voice Lab provides a workbench upon which the structure of speech can be analyzed and offers a library of system units that facilitate speech synthesis from application programs.

Voice Lab is neither a static nor a completed project. Its modular-unit structure is specifically designed to allow experimentation and further development. In the project's gestative phases, versions of the Voice Lab library have used ADPCM, (adaptive differential pulse-code modulation), DPCM, and PCM encoding. And at one point the Voice Messages unit employed a phonetic, rather than word-oriented vocabulary.

I'm still working on extensions to handle common word endings, such as plurals. Additionally, the results from the zero-crossing analysis and peak-energy plots have suggested some reasonable lines of inquiry into speech recognition, the other side of the voice-input/output problem.

I hope that I've encouraged you to push the limits of your computer and discover the frontiers of speech interaction.■

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Help in Apple III Pascal

This easy-to-implement Help system offers online instructions and explanations anywhere in a program

by Al Evans

The ideal computer program features online instructions and explanations that save time and reduce the probability of making errors. But adding complete documentation or a Help system to a computer such as the Apple III must not substantially increase the complexity and bulk of the software it serves. And such a system should be sufficiently fast and flexible to use anywhere in application software.

An ideal Help system is not easy to realize with most available low-cost hardware/software combinations. The one described here, however, is readily implemented because it takes advantage of the modular structure of UCSD Pascal and the Apple III's advanced console-control capabilities. It can be used anywhere in a program to provide needed information. Listing 1 shows a program that demonstrates this Help system.

System Definition

Before implementing a complete online Help system, it's important to consider the three basic areas within a program in which you might require additional information:

- *Help from the menu level.* Individual Help screens are attached to each menu item. Primarily instructional, they provide information about menu selection and describe its use or offer examples of the system's action when the item is selected.

"Infinite" interruptibility is required when you want to design a nearly ideal Help system.

- *Help during keyboard input.* During any request for input from the keyboard, detailed reminders describe what information you need to enter.
- *Help during a continuous process.* Help screens can be connected, for example, to procedures that display output to explain the data shown and/or its format.

Unfortunately, these situations cover a seemingly infinite variety of machine states and cannot be reduced to a small number of cases that could be handled individually. What is required, then, is "infinite" interruptibility. This capability is provided by a set of techniques that enable you to easily interrupt any process at any time but that don't require special programming for individual cases and don't affect the process being interrupted.

One technique, keypress sensing, is easily implemented on most computers. Another incorporates a set of procedures to save and restore the exact state of the console screen, including all displayed data and the cursor position. On many small systems, implementing these procedures would require assembly-language programming; the Apple III, however, supports them through calls to the .CONSOLE driver.

In addition to software-interrupt techniques, you'll need a method of

Listing 1: *A demonstration program of a Help system in Apple III Pascal.*

```
PROGRAM HELP_DEMO;
{By Al Evans, 1982. Public domain -- use freely, but please give me credit}

CONST

{Help table of contents; give each help screen a name and enter it here.}
  MENU1 = 1;
  MENU2 = 2;
  EX1 = 3;
  EX2 = 4;

TYPE Byte = 0..255;
     Buffer_2K = Packed Array[0..2048] of Byte;
     Request_Code = Packed Record
                      CHANNEL: 0..1;
                      STAT_OR_CTRL: 0..1;
                      REQUEST_NUM: 0..255;
                      RESERVED: 0..63
                    END;
     XY_Coordinates = (X, Y);
     Menu_Mode = (NORMAL_MODE, HELP_MODE);

VAR LEFT_ARROW, ESCAPE, HELP_KEY, BEEP: Char;
    KEY_BUF_STATUS, SCREEN_SAVE, SCREEN_RESTORE: Request_Code;
    SCREEN_POSITION: Request_Code;
    SCREEN_BUFFER: Buffer_2K;
    CURS_POS: Packed Array[XY_Coordinates] of Byte;
    INPUT_SET: Set of Char;

{------------------------ APPLE /// CONSOLE CONTROL ---------------------}

Procedure Clear_Screen;
BEGIN
 Write(Chr(28))
END;

Procedure Inverse;
BEGIN
  Write(Chr(18))
END;

Procedure Normal;
BEGIN
  Write(Chr(17))
END;

{Though the demonstration program does not use viewports, the next two
 procedures are required to provide HELP for programs that do.          }

Procedure Reset_Viewport;
BEGIN
  Write(Chr(1))
END;

Procedure Restore_Viewport;
BEGIN
  Write(Chr(4))
END;

Procedure Back_Space;
BEGIN
  Write(Chr(8))
END;

Procedure Save_Screen;
CONST CONSOLE = 1;
BEGIN
  Unit_Status(CONSOLE,SCREEN_BUFFER,SCREEN_SAVE);
  Unit_Status(CONSOLE,CURS_POS,SCREEN_POSITION)
END;

Procedure Restore_Screen;
CONST CONSOLE = 1;
BEGIN
  Unit_Status(CONSOLE,SCREEN_BUFFER,SCREEN_RESTORE);
  GotoXY(CURS_POS[X], CURS_POS[Y])
END;

Function Keypressed: Boolean;
CONST CONSOLE = 1;
VAR CHARS_AVAIL: 0..255;
BEGIN
  CHARS_AVAIL:= 0;
  Unit_status(CONSOLE,CHARS_AVAIL,KEY_BUF_STATUS);
  Keypressed:= CHARS_AVAIL > 0
END;

{----------------------------------------------------------------------}


Procedure Help(WHERE: Integer);
CONST
      {Enter the prefix for your HELP frames here}
      PREFIX = '/DEMO/FRAME';
      START_BLOCK = 0; {Change to 2 for Pascal text files}
      CONSOLE = 1;
```

Listing 1 continued on page 479

composing formatted Help screens and storing them as disk files. Any text editor that produces Pascal-compatible files will accomplish this step. We use Applewriter III (a word-processing program) or the Apple III Pascal editor set to ASCII (American National Standard Code for Information Interchange) mode to eliminate blocks of format data at the front of each UCSD Pascal text file because we don't need them for our purposes.

Finally, you'll need a way to get a screenful of formatted data quickly from a disk to the display. Providing this feature are the low-level Pascal procedures BLOCKREAD and UNITWRITE, which can be used to read and write large chunks of data regardless of type. In this case, they permit the system to find a Help frame on disk, read it, and display it on the screen in less than 3 seconds (or in much less time if a hard disk is used).

The System Design

To simplify use of the disk files containing the Help screens, the files are named systematically; the first is FRAME1, the second is FRAME2, and so on.

In the program's global-declarations section, a table of contents matches each program area for which Help is provided with its corresponding frame number. For example, a program in which the first two Help frames concern the first two items on the menu begins with the declaration

CONST MENU1 = 1;
MENU2 = 2; . . .etc.

The Help procedure itself is declared as

Procedure Help(WHERE: Integer);

Calls to this procedure in the form of "Help(MENU1)" are thus permitted.

In order for you to be able to use the Help facility, the program must have three additional features. First, it needs a dual-mode menu that can act as a normal menu for program control or as a menu for instructional Help screens. We use the global

TYPE declaration

TYPE Menu_Mode = (NORMAL_MODE, HELP_MODE);

to permit declaration of the menu itself, as

Procedure Menu(MODE: Menu_Mode);

and employ the parameter MODE within the menu itself to control its action. The main program calls the menu as Menu(NORMAL_MODE). If the Help key is pressed from within the menu, it makes a recursive call to itself as Menu(HELP_MODE).

The program also needs a string-reading procedure that emulates Readln but can be interrupted at any time to use the Help system during input. Because it must read one character at a time, it will also be used to filter nonprinting characters out of the input. This procedure is declared as

Procedure Get_String(VAR INPUT_LINE: String; CALLING_PROC: Integer);

INPUT_LINE is the string to be built by the procedure; CALLING_PROC is one of the above global constants representing the Help screen that applies to the calling procedure.

Finally, for Help during a continuous process, we insert the line

If Keypressed Then Handle_Key;

wherever the process is to be interrupted. To complete the procedure, we use such instructions as

```
Procedure Handle_Key;
VAR KEY: Char;
BEGIN
  Read(KEYBOARD,KEY);
  If KEY = HELP_KEY Then
    Help(WHEREVER);
  {. . . etc. for any special keys to be
    handled}
END;
```

Implementing the Help System

Having covered our three general cases, we implemented the system in

Listing 1 continued:

```
VAR FRAME: Buffer_2K;
    BLOCK_COUNT: Integer;
    HELP_FILE: File;
    FILE_NAME: String;
    KEY: Char;
    CH_TO_STR: String[1];

BEGIN
  Reset_Viewport;              {See note under Apple /// Console Control above}
  Save_Screen; Clear_Screen;
  Str(WHERE, FILE_NAME);
  FILE_NAME:= Concat(PREFIX, FILE_NAME);
  {$IOCHECK-}
  Reset(HELP_FILE, FILE_NAME);
  {$IOCHECK+}
  If IORESULT <> 0
  Then REPEAT
         Writeln(Chr(7),'Please put program disk online and press <RETURN>,');
         Writeln('Or press <ESCAPE> to exit: ');
         Read(KEY);
         If KEY = ESCAPE
         Then BEGIN
                Restore_Screen;
                Restore_Viewport;
                Exit(Help)
              END;
         Clear_Screen;
         {$IOCHECK-}
         Reset(HELP_FILE, FILE_NAME)
         {$IOCHECK+}
       UNTIL IORESULT = 0;
  BLOCK_COUNT:= Block_Read(HELP_FILE, FRAME, 4, START_BLOCK);
  Unit_write(CONSOLE, FRAME, (BLOCK_COUNT * 512), 0, 0);
  GotoXY(0,23); Write('Press any key to proceed');
  Read(KEY);
  Close(HELP_FILE);
  Restore_Screen;
  Restore_Viewport            {See above note concerning Reset_Viewport}
END;

Procedure Init_Variables;
BEGIN
  LEFT_ARROW:= Chr(8); BEEP:= Chr(7);
  ESCAPE:= Chr(27); HELP_KEY:= Chr(191); {Open-Apple-question-mark}
  INPUT_SET:= [Chr(32)..Chr(126)];
  With KEY_BUF_STATUS Do
    BEGIN
      CHANNEL:= 0;
      STAT_OR_CTRL:= 0;
      REQUEST_NUM:= 5;
      RESERVED:= 0
    END;
  With SCREEN_SAVE Do
    BEGIN
      CHANNEL:= 0;
      STAT_OR_CTRL:= 0;
      REQUEST_NUM:= 18;
      RESERVED:= 0
    END;
  With SCREEN_RESTORE Do
    BEGIN
      CHANNEL:= 0;
      STAT_OR_CTRL:= 1;
      REQUEST_NUM:= 18;
      RESERVED:= 0
    END;
  With SCREEN_POSITION Do
    BEGIN
      CHANNEL:= 0;
      STAT_OR_CTRL:= 0;
      REQUEST_NUM:= 16;
      RESERVED:= 0
    END
END;

{Use this procedure for interruptible string input.
 For demonstration purposes, enter it in the exact format shown so that
 it will fit into 23 lines.}

{EX2 BEGIN}
Procedure Get_String(VAR INPUT_LINE: String; CALLING_PROC: Integer);
VAR KEY: Char;   CH_TO_STRING: String[1];
BEGIN
  INPUT_LINE:= ''; CH_TO_STRING:= 'X';
  Read(KEYBOARD, KEY);
  While NOT EOLN(KEYBOARD) Do
  BEGIN
    If KEY = HELP_KEY Then Help(CALLING_PROC)
    Else If (KEY = LEFT_ARROW) AND (Length(INPUT_LINE) > 0)
         Then BEGIN
                Back_Space; Write(' '); Back_Space;
                INPUT_LINE:= Copy(INPUT_LINE, 1, Length(INPUT_LINE) - 1)
              END
         Else If KEY IN INPUT_SET
              Then BEGIN
                     Write(KEY); CH_TO_STRING[1]:= KEY;
                     INPUT_LINE:= Concat(INPUT_LINE, CH_TO_STRING)
                   END
```

Listing 1 continued on page 480

the Apple III. There it furnishes online Help from anywhere in the program in the form of a formatted screen display.

To use the system, the basic console-control procedures Save_Screen and Restore_Screen as well as the function Keypressed are required. Save_Screen stores the console display's contents in a globally declared 2K-byte buffer and puts the cursor coordinates into a 2-byte packed array. Restore_Screen reverses this process. Keypressed merely returns TRUE if a character is available to the Pascal system and FALSE if none is available (i.e., no key has been pressed).

On the Apple III, these operations are most easily performed using D_STATUS and D_CONTROL calls to the operating system via the Pascal UNITSTATUS procedure. (Refer to Listing 1 and the *Apple III Standard Device Driver's Manual*, pages 169 to 171, for more details.) The Pascal UNITSTATUS procedure is called as

```
UNITSTATUS(UNITNUMBER,
  STATUSLIST, REQUESTCODE);
```

UNITNUMBER is an expression with an integer value that is the Pascal unit number of an I/O (input/output) device (1 in the case of the .CONSOLE driver, for instance). STATUSLIST refers to a variable that contains or will contain the data to be passed to or from the device specified by UNITNUMBER (SCREEN_BUFFER, for example, in the case of Save_Screen and Restore_Screen). REQUESTCODE is a 16-bit packed record that indicates whether the device's input or output channel will be affected by the call, whether it is a status (D_STATUS) or control (D_CONTROL) call, and the type of status or control call being made. This record is declared as

```
Type Request_Code = Packed
  Record
  CHANNEL: 0..1;
  STAT_OR_CTRL: 0..1;
  REQUEST_NUM: 0..255;
  RESERVED: 0..63
END;
```

Listing 1 continued:

```
                  Else Write(BEEP);
      Read(KEYBOARD, KEY)
  END;
  Writeln
END; {Get_String}
{EX2 END}

{MENU1 PART 1 BEGIN}
Procedure Example1;

{An example of HELP during a continuous process, in this case a continuous
 screen display. HELP would normally be used in this instance to provide
 information on the format and/or meaning of the display.              }

VAR FOREVER: Boolean;
{MENU1 PART 1 END}

{EX1 BEGIN}
  Procedure Handle_Key;
  VAR KEY: Char;
  BEGIN
    Read(KEYBOARD, KEY);
    If KEY = HELP_KEY Then Help(EX1);
    If KEY = ESCAPE Then Exit(Example1)
  END;

  Procedure Slowprint(LINE: String);

  {This procedure is given as the extreme example of interruption during
   display -- the process can be interrupted after each character is dis-
   played. Of course the display would be much faster if written a line
   at a time and if "Keypressed" was checked only at the end of each line.}

  VAR CHAR_COUNT: Integer;
  BEGIN
    For CHAR_COUNT:= 1 to Length(LINE) Do
    BEGIN
      Write(LINE[CHAR_COUNT]);
      If Keypressed Then Handle_Key
    END
  END;
{EX1 END}

{MENU1 PART 2 BEGIN}
BEGIN {Example1}
  FOREVER:= FALSE;
  Clear_Screen;
  REPEAT
  Slowprint('This is an example of how HELP can be provided during an ');
  Slowprint('ongoing process. This text will simply be displayed repeatedly ');
  Slowprint('until you push <ESCAPE>. While it is being displayed, you can ');
  Slowprint('press ''<open-apple>?'', and whatever help screen you have
attached will ');
  Slowprint('be displayed instead. When you return to this display after ');
  Slowprint('reading the HELP display, the process will begin again exactly ');
  Slowprint('where it left off. ')
  UNTIL FOREVER
END;
{MENU1 PART 2 END}

{MENU2 BEGIN}
Procedure Example2;
VAR LINE: String;

BEGIN
  Clear_Screen;
  Writeln('This procedure demonstrates HELP during the input of a string');
  Writeln('from the keyboard. The HELP_KEY can be pressed any time during');
  Writeln('entry. Enter ''Stop'' when finished');
  REPEAT
    Write('Enter string: ');
    Get_String(LINE, EX2);                  {Example of a call to Get_String}
    Writeln('You entered: ',LINE)
  UNTIL LINE = 'Stop'
END;
{MENU2 END}

Procedure Menu(MODE: Menu_Mode);
VAR CHOICE: Char;
BEGIN
  REPEAT
    Clear_Screen;
    If MODE = NORMAL_MODE
    Then BEGIN
           GotoXY(65,23);
           Write('''<open-apple>?'' for HELP')
         END;
    GotoXY(0,4);
    Writeln(' ':5,'Demonstrations available:');
    Writeln;
    {Enter your menu here}
    Writeln(' ':5,'1) HELP during continuous output process');
    Writeln(' ':5,'2) HELP during input from keyboard');
    Writeln;
    If MODE = HELP_MODE
    Then BEGIN
           Write(' ':5);
           Inverse;
```

Listing 1 continued on page 481

Listing 1 continued:

```
        Write('Now in HELP mode. Choose topic for instructions.');
        Normal;
        Writeln
      END;
    Writeln(' ':5,'<ESCAPE> to quit');
    Write(' ':5,'Option: '); Read(CHOICE);
    If MODE = NORMAL_MODE
    Then Case CHOICE of
        {Enter your program's responses to menu choices here}
        '1': Example1;
        '2': Example2;
      END
    Else Case CHOICE of
        {Enter your menu's HELP frames here}
        '1': Help(MENU1);
        '2': Help(MENU2)
      END;
    If (MODE = NORMAL_MODE) AND (CHOICE = HELP_KEY)
    Then Menu(HELP_MODE)
  UNTIL CHOICE = ESCAPE
END;


BEGIN (*MAIN PROGRAM*)
  Init_Variables;
  Menu(NORMAL_MODE);
  Clear_Screen
END.
```

The specific request codes used as commands to the .CONSOLE device driver are declared as global variables (KEY_BUF_STATUS, SCREEN_SAVE, SCREEN_RESTORE, SCREEN_POSITION) of the type RequestCode and initialized in an Init_Variables procedure. The following instructions provide an example.

```
With SCREEN_SAVE Do
  BEGIN
    CHANNEL:= 0;
    STAT_OR_CTRL:= 0;
    REQUEST_NUM:= 18;
    RESERVED:= 0
  END;
```

Using the Help Procedure

The operation of the Help procedure itself is simple. It saves and clears the screen (and resets the viewport to include the full screen, although this action is not required by the demonstration program provided), then looks on the volume specified by PREFIX for a FRAME file with the frame number passed to it as the parameter WHERE. If it finds the file, it reads as many as four blocks (2048 characters, slightly more than one screenful) using Block_Read. Using Unit_Write, it writes the data all at once to the console. It then waits for a keypress, closes the file, and restores the screen and viewport to the state they were in when Help was called.

Before compilation, two constants in this procedure are set for each specific application. PREFIX is set to the complete volume and file name of the Help files through FRAME—for example, /DEMO/FRAME (or, in UCSD Pascal notation, DEMO: FRAME). The procedure concatenates the parameter WHERE to PREFIX, resulting in /DEMO/FRAME1, /DEMO/FRAME2, and so on. START_BLOCK is set to 0 for an ASCII file or to 2 for a Pascal text file to skip the two-block header.

You can install the Help system in any program by filling in the blanks.

Much of the procedure is dedicated to ensuring that the system doesn't crash if the disk containing the Help frames goes off line and to providing an Exit option if these files are unavailable. This portion (from If IORESULT < > 0. . . to . . .UNTIL IORESULT = 0, as well as the preceding {$IOCHECK−} and {$IOCHECK+}) can be eliminated if these files will always be on line (in a hard-disk system, for example).

The Demonstration Program

Enter the demonstration program, compile it, and execute it. Be sure to set the constant PREFIX in the Help procedure to the volume name of the disk you will use for the Help files plus /FRAME (e.g., /DEMO/FRAME). And note that the HELP_KEY used is Open-apple-question-mark [Chr (191)]. The Open-apple key is a kind of "supershift" key that adds 128 to the decimal equivalent of the ASCII code for any character typed with it. (Because the open apple is itself a nonprinting character on our printer, we changed all literal open apples in the program to <open-apple>. When you enter the program, these references should be replaced for display purposes with actual open apples, which are entered by typing control-shift-backslash.)

At this point, any call for Help should receive the answer "Please put program disk on line and press <RETURN> or press <ESCAPE> to exit." Otherwise, the program should operate in the following manner.

From the NORMAL_MODE menu, the first menu choice should result in a continuing text display that is interruptible only by pressing <ESCAPE> or "open-apple-question-mark." The second menu choice should demonstrate string entry (with echo for confirmation), which can be interrupted by entering an "open-apple-question-mark" with the same results as before and exited by entering the string "Stop." Entering "open-apple-question-mark" from the NORMAL_MODE menu brings up the HELP_MODE menu. Either choice from the HELP_MODE menu should produce "Please put program disk on line. . . ," and <ESCAPE> should return you to the NORMAL_MODE menu.

Now let's make some Help screens. For demonstration purposes, we'll use appropriate portions of the program itself. The following instructions are specifically applicable to the Apple III Pascal editor. Regardless of the editor, however, the objective is the same—to delete all except certain portions and to save these portions as ASCII text files. The operations required for any editor are very similar.

Read the program text file into the Pascal editor again, then set the editor to ASCII mode [S(et E(nviron-

ment A(sciifile T(rue <CTRL C>]. Note the comments {MENU1 PART1 BEGIN}, {MENU1 PART1 END}, {MENU1 PART2 BEGIN}, and {MENU1 PART2 END}. DELETE or ZAP everything in the program *except* these two sections, taking care not to leave any extra carriage returns at the beginning or end of the file. The file should begin at the first character and end immediately after the last character of the text to be used as the Help frame. Q(uit and W(rite the file to your disk as <name of your disk>/FRAME1. *Do not* use the S(ave option here, or you will lose the program text file.

Choose the C(hange files option and reload the complete program text. Repeat the entire process for MENU2, EX1, and EX2 (naming the Help files FRAME2, FRAME3, and FRAME4). When you execute the program and request Help, the display should show the applicable part of the source code.

Installing the Help System

You can install the Help system in any program by appropriately filling in the blanks. First, copy the type declarations, the global variables, the console control procedures, and the Init_Variables procedure directly into your program. Next, copy the Help procedure, setting the constant PREFIX to that for your own Help files and the constant START_BLOCK to 0 (for ASCII or data files) or 2 (for Pascal text files).

Then compose a table of contents of the Help screens to be provided and enter it in the program's global constants section. After that, insert calls to Help in the body of your program wherever Help is to be provided, and copy the procedure Get_String—to use wherever Help will be available during string input. Use the technique demonstrated by the procedure Example1 to provide Help anywhere else in your program. The next step is to copy the menu procedure, changing the entries, program actions, and HELP calls to fit your program.

Finally, use the Pascal editor or any other text editor that can write a formatted text file on disk to compose your Help frames, limiting each frame to 23 or fewer lines. Name the disk files FRAME1, FRAME2, and so on to match the values assigned to the help screens in the global constants section. If you are using Pascal text files, end all of these file names with periods to keep the editor from appending ".TEXT" to them.

When you are finished, ask someone who's unfamiliar with your system to use it to test its usefulness and completeness. Note that you can edit individual HELP frames as many times as necessary; recompile your program only if you are adding or eliminating frames or changing the locations of the HELP calls, the path name of the HELP files, or Pascal Text files to ASCII files.

When everything is perfect, you can relax in the knowledge that help is always available.■

Al Evans (1206 Karen Ave., Austin, TX 78757) is the owner of PowerTools, a small research company primarily engaged in developing new approaches to Software design and computer use.

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TERMINALS

Televideo 925	$695.00
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Circle 300 on inquiry card.

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Ask BYTE

Conducted by Steve Ciarcia

Under-$50 Modem Configured for CCITT

Dear Steve,

I built your "modem for under $50" and modified it for use with CCITT frequencies, which are standard in South Africa. (See "A Build-It-Yourself Modem for Under $50," August 1980 BYTE, page 22.) I also expanded it to allow switching between answer and originate modes. What follows shows that the additional modifications cost less than $5.

The main feature of my design lies in the use of CMOS (complementary metal-oxide semiconductor) bilateral analog switches (CD4066, MC14066, etc.). These allow all switching to be done on the printed-circuit board, controlled by a SPDT (single-pole, double-throw) switch on the front panel. As the 4066 is variously described as having a maximum supply voltage of 15 or 18 V (volts), I designed my circuit to work off +5 and −5-V supplies. I found no difficulty in operating the XR2211 at 5 V.

Table 1 shows the comparison between the Bell system and the CCITT frequencies. For the CCITT system, the higher frequency is the space code, which is the reverse of the Bell system. To get around this, I simply moved gate (c) of the 4011 in your design to invert the output of IC4(b) before entering IC7. Q3 now feeds directly to Q2 via a 4.7k resistor.

Referring to your parameter-value equations for the bandpass filters in figure 3 (page 32), it is seen that for a fixed capacitance C:

(1) bandwidth is defined by R3
(2) gain is defined by R1
(3) center frequency is determined by R2.

I left the bandwidth the same. After some juggling I came up with R1 = 4.7k (which increases the gain somewhat) and the following values for R2:

fo = 1080 R2 = 2943
fo = 1750 R2 = 808

The on-resistance of a 4066 is around 90 to 110 ohms. After some experimentation, we get to the practical circuit in figure 1 (repeated twice).

	Originate		Answer	
	Bell	CCITT	Bell	CCITT
Mark	1270	980	2225	1650
Space	1070	1180	2025	1850

Table 1: *Comparison of Bell standard and CCITT frequencies.*

As mentioned above, the 4066 is supplied from +5 and −5 V to encompass equal swings above and below ground potential. The actual swing is very small. Up to this point, only half a 4066 package is required to switch the bandpass filter between originate and answer modes.

I kept the demodulator's timing capacitor Co constant at 0.022μF (microfarad). This gave me the following values for Ro:

fo = 1080 Ro = 42087
fo = 1750 Ro = 25974

This is realized in practice as shown in figure 2. I altered R1 to 220k and C_D to 0.068μF. Your original component value for C_F of 0.005μF does not match up with EXAR's design sheets, but I agree that it works better.

In the modulator section, the center frequency for the NE567/XR567 triangular-wave oscillator is given approximately by f = 1/RC. If R is held constant, then for frequencies f1 and f2 capacitances C1 and C2 would be required as follows:

$$\frac{C1}{C2} = \frac{f2}{f1}$$

Your original design had:

$$\frac{C1}{C2} = \frac{25.7}{22} = 1.168$$

where:

$$\frac{f2}{f1} = \frac{1270}{1070} = 1.187$$

This is close enough, particularly considering the tolerances of the components. I retained these capacitor values for the

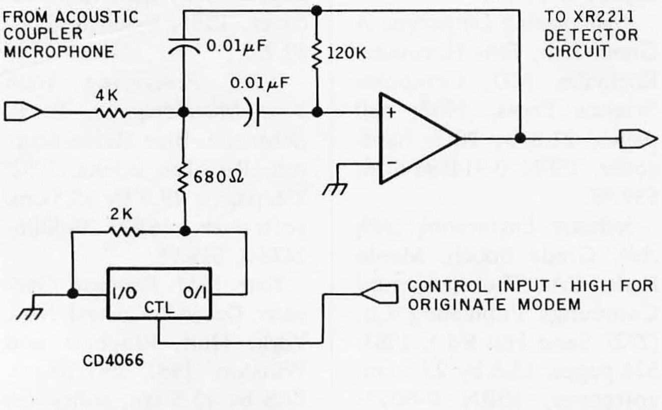

Figure 1: *Solid-state switch alters microphone-driven filter to allow either answer or originate modes. The switch is a CMOS 4066 type.*

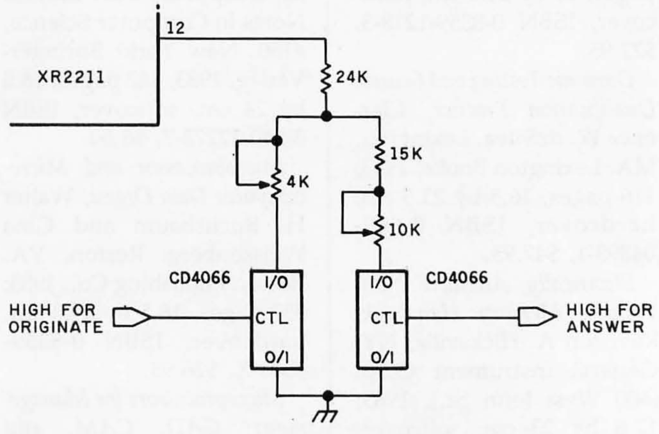

Figure 2: *Demodulator-control circuit modified to allow switching between answer and originate modes.*

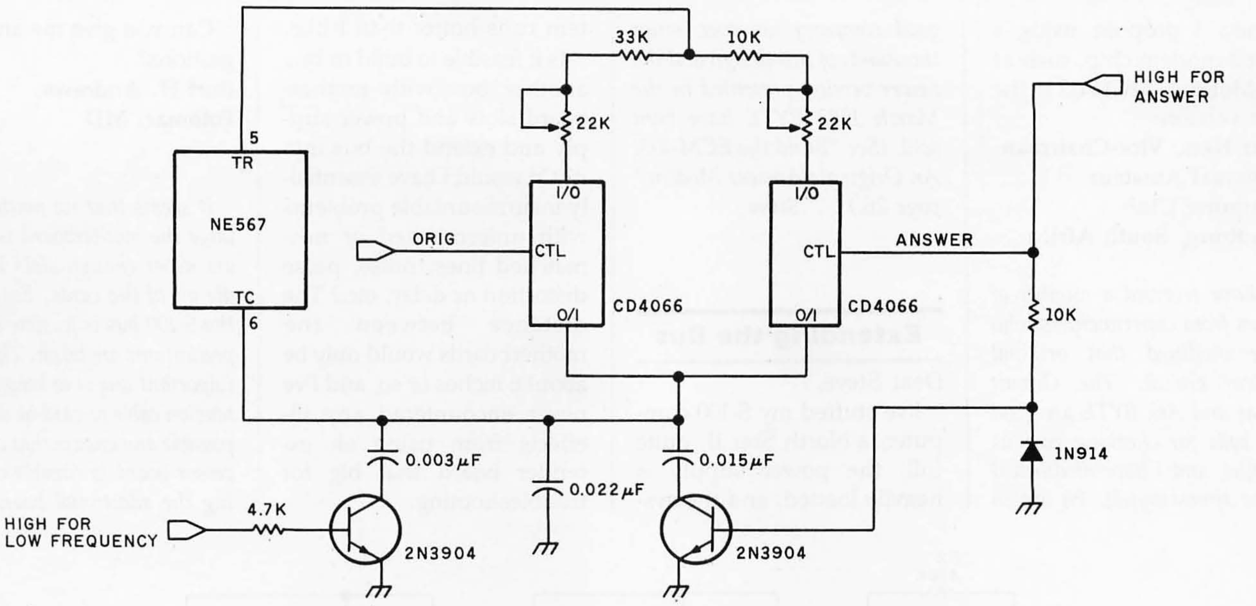

Figure 3: *Answer or originate tones are modulated by simple control signals.*

originate mode, where our frequencies give:

$$\frac{f2}{f1} = \frac{1850}{1650} = 1.12$$

This still appears satisfactory.

For the answer mode, I switched in an additional capacitor of 0.015μF in parallel and a different preset potentiometer. This gives us:

$$\frac{f2}{f1} = \frac{1180}{1190} = 1.204$$

and:

$$\frac{C1}{C2} = \frac{40.7}{37} = 37 = 1.100$$

This does not look very good, but works quite well in practice, helped a little by the fact that the original formula f = 1/RC is not quite correct. I therefore have the circuit shown in figure 3.

I used one 4066 gate to invert the control switch signal, as some analog switches are on while others are off. The final 4066 gate was then used to hold the transmit carrier permanently on when in answer mode.

I have constructed 22 of these modems to date, without major difficulties. Minor problems all revolve around the use of a 4011 in the linear mode: the gate handling Carrier Detect tends to oscillate for a time while changing state and affects the other gates in the package. Also, A-type CMOS is definitely not suitable. I would like to extend the time delay on the Carrier Detect, but this is not practical for the same reason. The mid-frequency of the filters tends to shift with component tolerances, but all have worked so far. My complete circuit is diagrammed in figure 4, page 286-287.

The circuit can be improved still further, but this will increase the component count even more. For my

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1 What should you do to control bleeding from a wound?

a Apply pressure directly over the wound.
b Run cold water over the wound.
c Apply a tourniquet.

2 Overweight individuals are at greater risk for:

a Diabetes.
b Gall bladder disease.
c High blood pressure.
d All of the above.

3 The best place to check the pulse in an emergency is at the:

a Upper arm.
b Neck.
c Wrist.
d Thigh.

4 What are the most common symptoms of high blood pressure?

a Dizziness.
b Headaches.
c Heart palpitations.
d No symptoms, usually.

ANSWERS: (1)a (2)d (3)b (4)d
Score 25 points for each correct answer.
100 — Excellent: Your answers show you're aware of the importance of maintaining good health.
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money, I propose using a digital modem chip, such as the Motorola MC14412 in the next version.

Peter Hers, Vice-Chairman
Transvaal Amateur Computer Club
Randburg, South Africa

I have received a number of letters from experimenters who have modified that original modem circuit. The Circuit Cellar and Ask BYTE are good test beds for checking various designs, and I have modified it a few times myself. We are in good company however, since thousands of this design and the newer version presented in the March 1983 BYTE have been sold. (See "Build the ECM-103, An Originate/Answer Modem," page 26.) . . .**Steve**

Extending the Bus

Dear Steve,

I've stuffed my S-100 computer, a North Star II, quite full, the power supply is heavily loaded, and the system runs hotter than I like.

Is it feasible to build or buy another box with motherboard slots and power supply and extend the bus into it? Or would I have essentially insurmountable problems with unterminated or mismatched lines, noise, pulse distortion or delay, etc.? The distance between the motherboards would only be about 6 inches or so, and I've never encountered any ill-effects from using an extender board that big for troubleshooting.

Can you give me any suggestions?

Burt H. Andrews
Potomac, MD

It seems that no matter how large the motherboard is, there are never enough slots to handle all of the cards. Extending the S-100 bus is feasible if some precautions are taken. The most important one is to keep the extension cable or card as short as possible and ensure that the processor board is capable of driving the additional boards.

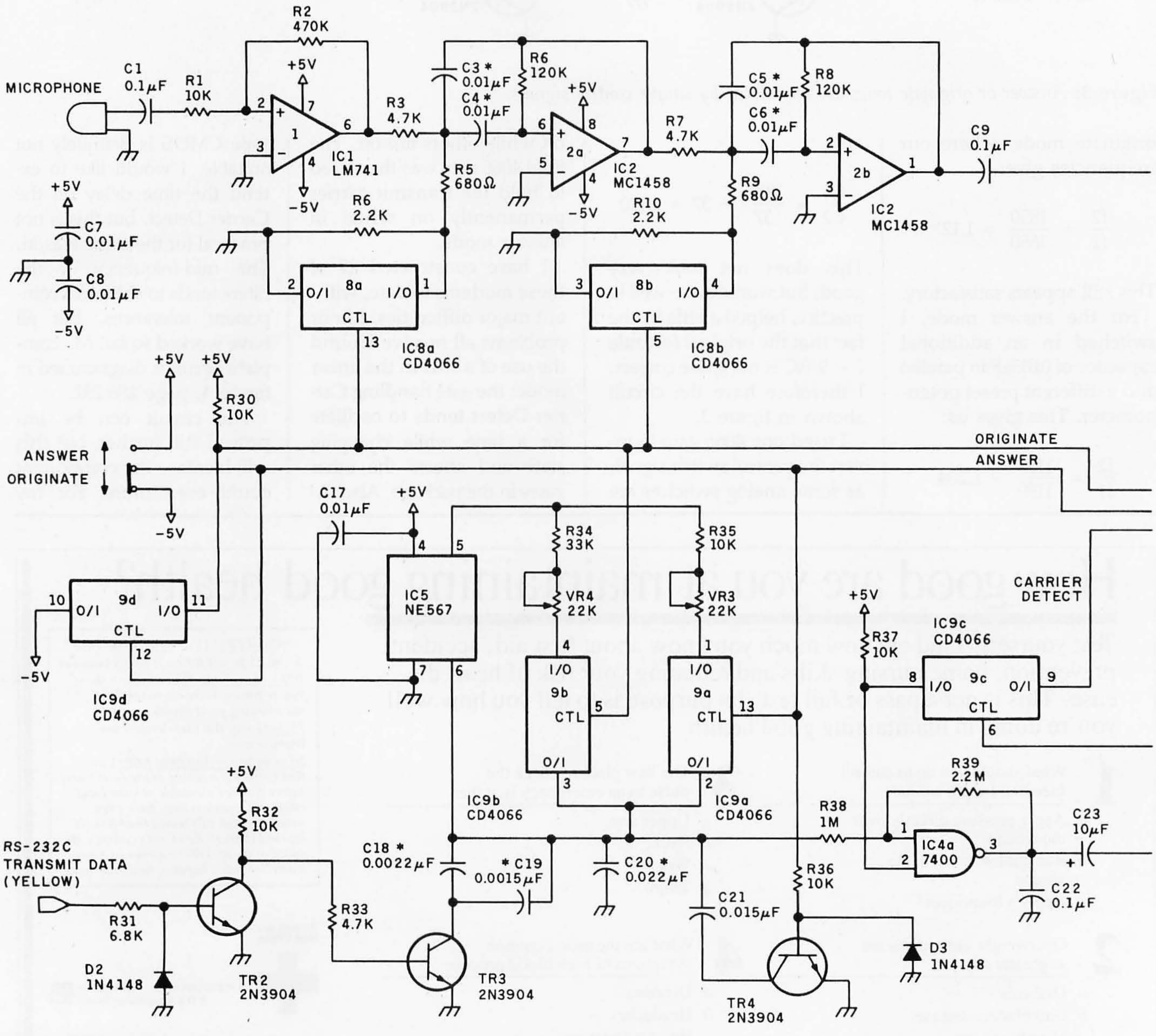


Figure 4: *The complete modem circuit as modified for Answer and Originate CCITT.*

If a separate power supply is used, tie it to the new expansion board only. Naturally, the two units should have a common ground.

To minimize noise on the bus, some form of termination, either active or passive, should be incorporated. Placing the processor board near the middle of the two units will effectively reduce the length of the bus. You might consider mounting the two motherboards back-to-back. This would allow the interbus board connection to be less than an inch. . . . **Steve**

Humidity Detection

Dear Steve,

I have a digital clock and thermometer module but I also want to be able to monitor humidity. What kind of sensing device can I use for this?

Dennis C. White
Whiteman AFB, MO

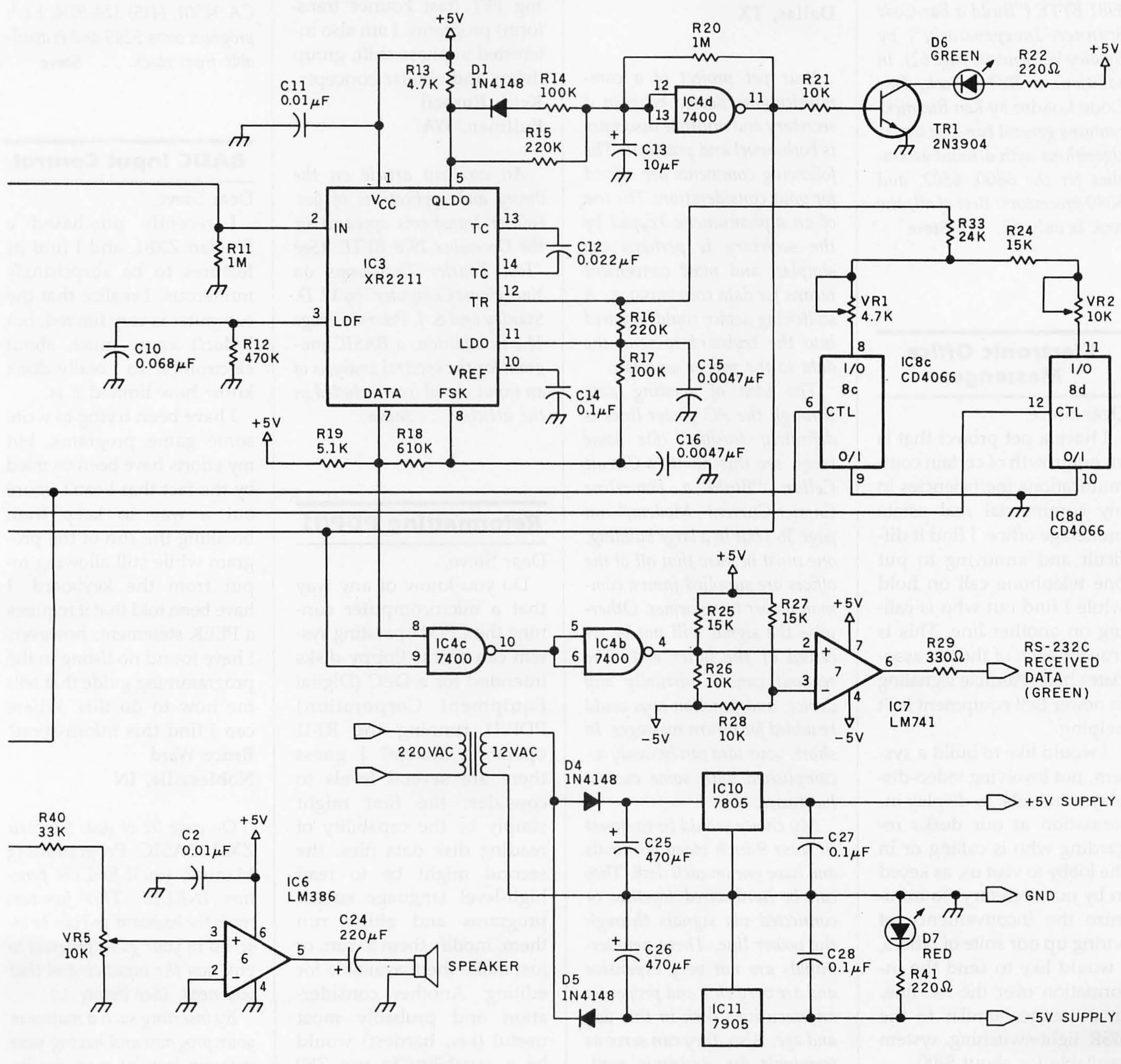
Of the several means of measuring humidity (wet and dry bulb thermometers, horsehair hygrometers, etc.), the simplest method is to use a humidty-sensitive resistance element. One such unit is the Model PCRC-11 manufactured by Phys-Chemical Research Corp., 36 West 20th St., New York, NY 10011, (212) 924-2070. It consists of a chemically treated styrene copolymer. It responds very rapidly because its humidity-sensitive portion is at the surface.

A circuit using this element was described in the June 5, 1980 issue of EDN magazine. (See "An Elegant 6-IC Circuit Gauges Relative Humidity" by Jim Williams.) The output is a DC voltage from 0 to 10 V for a humidity range of 0 to 100%, and the circuit features an overall 2% accuracy. The 0 to 10-V output can be fed to a voltage-to-frequency converter and counted by a simple computer program to read relative humidity. According to the article, the unit cost about $30. . . . **Steve**

Bar-Code Reader for Popular Computers

Dear Steve,

Do you know where I can



buy an inexpensive (less than $225) bar-code reader that I can use with my Osborne 1?
Rich Weiss
Fullerton, CA

I am not aware of a bar-code reader made exclusively for the Osborne 1, but Hewlett-Packard makes a Digital Wand, called the Model HEDS-3000. It sells for around $100 and can be interfaced to any computer.

An article describing the construction and interfacing of such a unit appeared in the November 1981 BYTE ("Build a Bar-Code Scanner Inexpensively" by Bradley W. Bennett, page 62). In addition, a BYTE Book, Bar Code Loader *by Ken Budnick, contains general bar-code loader algorithms with detailed assemblies for the 6800, 6502, and 8080 processors. Best of all, the book is only $2. . . .* **Steve**

Electronic Office Messenger

Dear Steve,

I have a pet project that is an outgrowth of certain communications inefficiencies in my commercial real estate brokerage office. I find it difficult and annoying to put one telephone call on hold while I find out who is calling on another line. This is true for each of the ten associates here. Audible signaling in newer Bell equipment isn't helping.

I would like to build a system, not involving video-display terminals, to display information at our desks regarding who is calling or in the lobby to visit us, as keyed in by our secretary. To minimize the inconvenience of wiring up our suite of offices, I would like to send the information over the AC line, in a manner similar to the BSR light-switching system available for about $100.

If this goes together and is well received in my company, I would like to sell systems to other companies as a subsidiary activity, and could capitalize such a subsidiary with $50,000 or so. Therefore I have sent in a patent preliminary application to see if anything in this system idea is novel enough to protect.

My hobbyist activities have been on the level of building Heathkits. I would appreciate any direction you might be able to provide in this matter.
J. Ross Millie
Dallas, TX

Your pet project of a communications device between a secretary and multiple associates is both novel and practical. The following comments are offered for your consideration: The use of an alphanumeric keypad by the secretary is perhaps the simplest and most convenient means for data transmission. A switching device could be wired into the keyboard to send the data to the proper associate.

The idea of sending data through the AC power lines is definitely feasible (for some ideas, see this month's Circuit Cellar, "Build a Powerline Carrier-Current Modem," on page 36) but in a large building, one must be sure that all of the offices are supplied from a common power transformer. Otherwise the signal will not be received at the other end. The readout can be virtually any device, and function keys could be added for return messages. In short, your idea can be easily accomplished with some custom hardware.

My choice would be to invest in some 9-inch video terminals and have one on each desk. They can be hard-wired together or connected via signals through the power line. These new terminals are not very expensive and are very chic and proper on an executive's desk in this day and age. Also, they can serve as terminals for electronic mail, stock market quotes, or whatever data your company may require.

With the increased usage of computers in the office, a small investment now will pay off very quickly and will allow easy expansion to more sophisticated systems. . . . **Steve**

FFTs on Home Computers

Dear Steve,

I would like to know how to analyze audio signals using FFT (fast Fourier transform) programs. I am also interested in phase shift, group delay, and similar concepts.
Keith Russell
Pullman, WA

An excellent article on the theory and applications of fast Fourier transforms appeared in the December 1978 BYTE. (See "Fast Fourier Transforms on Your Home Computer" by W. D. Stanley and S. J. Peterson, page 14.) In addition, a BASIC program for the spectral analysis of an input signal was included in the article. . . . **Steve**

Reformatting PDP/11

Dear Steve,

Do you know of any way that a microcomputer running the CP/M operating system can access floppy disks intended for a DEC (Digital Equipment Corporation) PDP/11 running the RT-11 operating system? I guess there are several levels to consider: the first might simply be the capability of reading disk data files; the second might be to read high-level language source programs and either run them, modify them to run, or just make them available for editing. Another consideration and probably most useful (i.e., hardest) would be a capability to use Z80 machine-language programs either by translating them or emulating a CP/M machine. Thank you for your help.
Barbara Olsen
Belchertown, MA

I know of two programs, called Reformatter, that will allow reading and writing IBM 3740- or DEC RT-11-formatted disks on a CP/M system. They feature bidirectional data transfer and full directory manipulation. The programs can be obtained from Microtech Exports Inc., Suite 2, 467 Hamilton Ave., Palo Alto, CA 94301, (415) 324-9114. Each program costs $249 and is available from stock. . . . **Steve**

BASIC Input Control

Dear Steve,

I recently purchased a Sinclair ZX81, and I find its features to be surprisingly numerous. I realize that the computer is very limited, but I don't know much about electronics, so I really don't know how limited it is.

I have been trying to write some game programs, but my efforts have been stymied by the fact that I can't figure out a way to keep from breaking the run of the program while still allowing input from the keyboard. I have been told that it requires a PEEK statement; however, I have found no listing in the programming guide that tells me how to do this. Where can I find this information?
Bruce Ward
Noblesville, IN

On page 92 of your Sinclair ZX81 BASIC Programming Manual, *you'll find the function INKEY$. This function reads the keyboard and can be inserted in your game program to give you the input control that you need. (See listing 1.)*

By inserting such a routine in your program and having your program loop by every few in-

Listing 1: *An example of the function INKEY$ in ZX81 BASIC.*

```
100 LET A$=INKEY$
105 REM PRESS T TO TURN OBJECT ON SCREEN
110 IF A$="T" THEN GOTO 200
115 REM PRESS S TO STOP OBJECT ON SCREEN
120 IF A$="S" THEN GOTO 300
.
.
.
200 TURN ROUTINE
.
.
.
300 STOP ROUTINE

ETC
```

structions, you can monitor the keyboard for instant input to change the action. . . . **Steve**

Two in the Hand

Dear Steve,

I own a TRS-80 Model I and would like to buy the documentation to Visicalc. What books would you suggest? Also, I want to buy a second floppy-disk drive. Should I buy a 40-track unit when all of my disks have been formatted on a 35-track drive?

Ian Buda
Flushing, NY

An excellent book for Visicalc documentation is The Power of Visicalc, *by Robert Williams and Bruce Taylor (Management Information Source, 1626 North Vancouver Ave., Portland, OR 97227).*

A 40-track unit will work fine with 35-track formatted disks. The 40-track unit will simply have five extra tracks. The disk-controller hardware and/or software controls the head position of the disk, so you will not automatically gain additional storage when you plug in the new drive. . . . **Steve**

Inexpensive Homebrew Terminals

Dear Steve,

I am trying to put together an inexpensive terminal to use a local university's computer from my home. My target expense is $200. After reading your articles on the Comm-80 ("I/O Expansion for the TRS-80," June 1980 BYTE, page 42) and "A Build-It-Yourself Modem for Under $50" (August 1980 BYTE, page 22), I've come up with a few ideas:

Get the Sinclair ZX81, build the appropriate serial interface and modem; or I can get an RCA 606 serial keyboard and build the required video interface and modem.

I would appreciate it if you could provide me with some better sources for my project.

Bill Chau
San Francisco, CA

Your goal of an under-$200 terminal can be achieved in several ways. The use of the Sinclair ZX81 with a modem and serial interface is an excellent idea and offers the ability to add "smart terminal" capability if it becomes necessary. It appears to be the easiest to construct and debug.

The RCA 606 serial keyboard with modem and video interface will also achieve your goal but requires more building and debugging time. Your time and available test equipment may figure in your decision.

In my February 1983 Circuit Cellar article, I described a low-cost terminal for use with the Z8 microcomputer. (See "Build a Handheld LCD Terminal," page 54.) It featured a one-line LCD display and should fall within your $200 limit if you are frugal. I am not certain, however, if the small display is acceptable for your needs.

You may also want to consider the Skul-Tek terminal kit. It is a circuit board that, when assembled, provides all the electronics for an 80-line by 24-character video terminal. It is available for $179 from Romac Computer Equipment, 240 West Market St., POB 589, Somonauk, IL 60552. One drawback is that you would still need to buy a video monitor, so the total may be beyond your budget. John Bell Engineering sells a similar unit that costs $199.95 assembled and tested. Contact John Bell Engineering Inc., 1014 Center St., San Carlos, CA 94070, (415) 592-8411. . . . **Steve■**

In "Ask BYTE," Steve Ciarcia answers questions on any area of microcomputing. The most representative questions received each month will be answered and published. Do you have a nagging problem? Send your inquiry to:

Ask BYTE
c/o Steve Ciarcia
POB 582
Glastonbury CT 06033

If you are a subscriber to The Source, chat with Steve (TCE317) directly. Due to the high volume of inquiries, personal replies cannot be given. Be sure to include "Ask BYTE" in the address.

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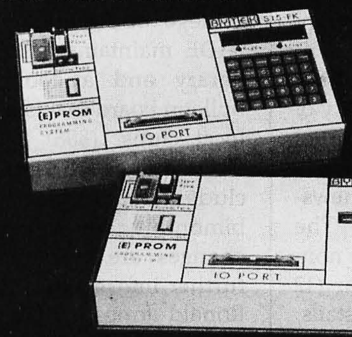

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Clubs and Newsletters

Fortune in the Bay Area

A nonprofit users group for owners of the Fortune 32:16 computer (/fug) meets regularly in the San Francisco Bay Area and produces a newsletter entitled *Fortune Users Group*. New members are welcome. For further details, write to Ned Hamilton, (/fug), POB 1501, Lafayette, CA 94549, or call (415) 283-1885.

Apple III Users Group

Adam's Apple, a nonprofit organization for Apple III users, offers a free first-year membership and graphic software to all Apple III owners. For information, send a large self-addressed, stamped envelope to David Adams, Adam's Apple III, POB 3151, Redwood City, CA 94064.

Northern VA Atari Users

NOVATARI, an Atari users group in Northern Virginia, meets on the second Sunday of the month in Chantilly, Virginia. Members have access to a program library of disks and tapes. Annual dues are $15 and include a subscription to the newsletter, *Current Notes*. The newsletter is available to nonmembers for $12 a year (12 issues). For more details, contact Tim Kilby, NOVATARI Users Group, Rt. 1, Box 288-B, Sperryville, VA 22740.

Newsletter Focuses on Home Control

The *Microcomputer Home Control Newsletter* is a quarterly publication that covers hardware and software applications for home control: telecommunications, security, monitoring utilities, and evaluations of new products. It costs $9.97 a year. For information, write to Russ Eberhart, POB 797, Columbia, MD 21044.

Overseas Communication

The Japan Microcomputer Club in Tokyo welcomes new members, user group information, and newsletters from microcomputer users groups from around the world. For details, contact Keigo Aono, Japan Microcomputer Club, Room 313, 3-5-8 Shibakoen, Minato-Ku, Tokyo 105, Japan, tel.: 03-438-1869 or Telex: CICC J27544.

Amarillo Apples

Apple Information and Data Exchange (AIDE), an affiliate of the International Apple Corps (IAC), meets on the second Thursday of each month at 7 p.m. at Amarillo College in Amarillo, Texas. AIDE maintains a software library and a cooperative bulletin board that is open to local clubs, (806) 374-9711. Annual dues are $15 and include a subscription to a bimonthly newsletter. Exchanges are welcome. For further information, contact Ronald Jones, AIDE, POB 30878, Amarillo, TX 79120, or call (806) 352-7934.

Ventura County, California

The Cabrillo Computer Club (formerly the Ventura County TRS-80 Computer Club) produces a monthly newsletter, *Micro Info Exchange*, and supports a bulletin-board service, called the Data Express, that has more than 40 programs. The club meets monthly and sponsors a 24-hour dedicated phone line and occasional swapmeets. For details, write to Glenn Bennett, Cabrillo Computer Club of Ventura County, POB 3032, Camarillo, CA 93011.

Meet in the Southeast of Michigan

General meetings of the South Eastern Michigan Computer Organization (SEMCO) are held each month. SEMCO is a nonprofit organization and charter member of the Midwest Affiliation of Computer Clubs (MACC). A $10 annual membership entitles you to a subscription to SEMCO's newsletter, *Data Bus*. Newsletter exchanges are welcome. All correspondence relative to SEMCO may be addressed to SEMCO, POB 02426, Detroit, MI 48202; inquiries about the newsletter should be addressed to *Data Bus*, Frank Voss, POB 43, Wyandotte, MI 48192.

Computerists Meet in San Diego

Anyone interested in computing is welcome to attend the monthly meetings of the San Diego Computer Society. The club maintains a community bulletin-board system for use by members and produces a monthly newsletter, *Personal Systems*. Annual membership costs $15 in the U.S., $25 overseas, and includes a subscription to the newsletter. For further information, write to the San Diego Computer Society, POB 81537, San Diego, CA 92138.

International Science Exchange

The Scientific Microcomputing Association at the University of Lyon in France welcomes any scientific computer users, particularly Apple users. Scientists are encouraged to exchange information about scientific calculations, graphics, languages, computer communications, and experiments. For information, contact Dr. Yves Boudeville, IRC-CNRS, 2 Avenue Albert Einstein, 69626 Villeurbanne, Cedex, France.

Hardcore Computing in the Northwest

Hardcore Computing, a newsletter produced every month by Softkey Publishing, contains software reviews, technical notes, and programs. Subscriptions are $20 in the U.S., $29 in Canada; foreign rates vary. Sample copies are available for $5 in the U.S. and $8 elsewhere. For details, write to *Hardcore Computing*, Softkey Publishing, POB 44549, Tacoma, WA 98444, or call (206) 581-6038.

Educators: Save Time

The Digest of Software Reviews: Education is a quarterly journal containing abstracts of selected, indexed reviews on educational software packages. Annual subscriptions are $43.95; discounts are available for

schools, colleges, and educators. For information, contact *The Digest of Software Reviews: Education*, School and Home Courseware Inc., Suite C, 1341 Bulldog Lane, Fresno, CA 93710, or call (209) 227-4341.

For Elementary and High Schools

The National Educational Computer Library (NECOL) is a nonprofit educational organization dedicated to assisting schools nationwide in meeting computer needs. The organization produces the *National Educational Computer Review* five times a year. For further details, write to the National Educational Computer Library, POB 293, New Milford, CT 06776, or call (203) 354-7760.

CPUP News from ETUG

The ET-3400 Users Group (ETUG) is a nonprofit, independent source of information about the Heath Company ET/ETA-3400 microprocessor trainer. Both new and experienced computer users are invited to become members. Dues are $16 in the U.S. and Canada and $22 elsewhere. Membership entitles you to receive the quarterly newsletter, *CPUP News*. Submitted articles and newsletter exchanges are welcome. Write to ETUG, 11231 Oak St., El Monte, CA 91731.

ETUG Chapter in Los Angeles

Owners of the Heath Company ET/ETA-3400, who live in southern California, can attend monthly meetings of the Los Angeles Chapter of the ET-3400 Users Group (LAETUG) at the Heathkit Electronic Center, 2309 South Flower, Los Angeles, CA 90007. For further information, call Gilbert Murillo at (213) 749-0261.

Electronic Business Bonus

Computer Comps provides programs and information for real-estate professionals, appraisers, investors, syndicators, brokers, managers, and attorneys. The $20 annual membership fee includes a newsletter, access to a database, electronic mail, Telex services, and group purchase discounts. For details, call Jim Clyde at (914) 358-2335 or 358-7102 (computer), or write Computer Comps, 48 Burd St., Nyack, NY 10960.

Atari Group on North Shore

Owners and users of the Atari 400/800 personal home computer are welcome to join a group on the Massachusetts North Shore. Users exchange information on getting the most from their Atari. For details, send a self-addressed, stamped envelope to the North Shore Atari Computer Users Group, POB 2052, West Peabody, MA 01960, or call Joseph Birkner at (617) 535-3749.

Informed Apple Users

The Central Ill Apple Users Group (CIA) meets on the second Tuesday of each month at 6:30 p.m. in the Peoria Public Library in Peoria, Illinois, to discuss Apple-related topics. A newsletter, the *CIA Informer*, is produced and newsletter exchanges are welcome. For details, contact the Central Ill Apple Users Group, POB 1462, Peoria, IL 61602.

GTE Telenet Reports

The *GTE Telenet Report* is a monthly tabloid produced by GTE Telenet Communications Corporation that contains national and international news on communications. For details, write to the GTE Telenet Communications Corp., 8229 Boone Blvd., Vienna, VA 22180.

Big K, Little k

Little k is a bimonthly newsletter produced by Poundfoolish Publications for pocket-computer users. It includes reviews of tested programs, software, and information for program authors. A sample issue is $1.50; an annual subscription is $12. For information, write to *Little k*, POB 75, Dubuque, IA 52001.

Atari Users Meet in West Valley

The West Valley Atari Users Group (WVAUG) welcomes users of Atari computers. Separate monthly meetings are held for both experienced and novice users. Membership dues are $12 a year, which includes a monthly newsletter, access to the disk library maintained by the club, and discounts on purchases. For details, contact Larry Stemke, WVAUG, 19400 Lemay St., Reseda, CA 91335.

Long Islanders Meet

An IBM Personal Computer users subgroup of the Long Island Computer Association (IBM PC LICA) meets on the second Friday of every month on the campus of the New York Institute of Technology, Commack, New York, in room 10. For details, contact Marvin Friefeld, 3 Lyndron Ave., Smithtown, NY 11787, or call (516) 724-0574 between 5 and 10 p.m. weekdays.■

If you would like BYTE readers to know about your club or newsletter send the details accompanied by no more than one newsletter to Clubs and Newsletters, BYTE Publications, POB 372, Hancock, NH 03449. Overseas groups are encouraged to participate. Please allow at least three months for your announcement to appear.

BYTE's Bits

TI to Service Tymshare Equipment

In mid-March, Tymshare entered an agreement with Texas Instruments whereby TI will handle maintenance calls and equipment repairs for users of Tymshare-supplied equipment. For repair work, users can call (800) 231-3128, or in Texas, (800) 572-3300, 24 hours a day, 7 days a week. Because Tymshare supplies its customers with computer hardware from a variety of manufacturers, this single-source maintenance service frees users from having to locate several different companies when problems arise.

Tymshare is an international telecommunications and information-management company. Corporate headquarters are located at 20705 Valley Green Dr., Cupertino, CA 95014, (408) 446-6000.■

Software Received

Apple

Alcor Pascal, a compiled language. This implementation of the Pascal language requires that programs be translated to an object format. It includes guides, a tutorial, and a master index. For the Apple II with CP/M; floppy disk, $199. Alcor Systems, 800 West Garland Ave. #204, Garland, TX 75040.

The Bank Street Writer, a children's word-processing program. This classroom-oriented program makes it easier to type, revise, store, retrieve, and print text. Three disks are included with documentation, a teacher's reference guide, and a section for students. For the Apple II and IIe; floppy disk, $95. Scholastic Inc., 730 Broadway, New York, NY 10003.

Boa, an arcade-type game. Recover the jewel of your king hidden in mazelike caverns using high-resolution graphics, sound effects, and a continuous musical score. For the Apple II; floppy disk, $29.95. Micro Magic, Suite C, 908 Memorial Parkway NW, Huntsville, AL 35801.

Chargen V1.0, a character-generator program for television production. It includes a production display program and an automatic display program for bulletin-board type applications. For the Apple II; floppy disk, $125. Boston Media Consultants, 19 Damon Rd., Scituate, MA 02066.

College Directions, a program that helps college-bound individuals choose from 1300 four-year colleges and universities based on individual interests and college assessments. For the Apple II and II Plus; floppy disk, $250. Systems Design Associates Inc., 723 Kanwha Blvd. E, Charleston, WV 25301.

The Dark Crystal, a fantasy-adventure game in which you journey through a make-believe land. Using the computer as your hands, feet, eyes, and ears you must restore a shard of the crystal to its place and solve a series of puzzles. For the Apple II and II Plus; floppy disk, $39.95. Sierra/On-Line Inc., 36575 Mudge Ranch Rd., Coarsegold, CA 93614.

File-Fax 2.0, a database-management program that includes user-friendly applications such as inventory control, customer files, mailing lists, purchase records, and more. For the Apple II and II Plus; floppy disk, $149. TMQ Software Inc., 82 Fox Hill Dr., Buffalo Grove, IL 60090.

Financial Facts, a series of tools that instantly computes the majority of data needed in personal and small-business financial management. It contains 20 programs including up-to-date depreciation methods. For the Apple II and II Plus; floppy disk, $59.95. Howard W. Sams & Co. Inc., 4300 West 62nd St., Indianapolis, IN 46268.

Krell's College Board SAT Preparation Series, an educational-testing program. Prepare students for high school SAT exams by diagnosing skill areas and planning drill and practice in the areas where the student needs it most. For the Apple II; floppy disk, $299.95. Krell Software Corp., 1320 Stony Brook Rd., Stony Brook, NY 11790.

The Latin Hangman, an educational game. This variation on the Hangman game teaches Latin words and terminology. For the Apple II; floppy disk, $29.95. George Earl, 1302 South General McMullen, San Antonio, TX 78237.

Math Blaster, an educational program that develops basic mathematical skills in students ages 6 through 12. It contains 600 problems in math functions, fractions, and percents as well as an editor and an arcade game. For the Apple II, II Plus, and IIe; floppy disk, $49.95. Davidson and Associates, 6069 Groveoak Place #14, Rancho Palos Verdes, CA 90274.

The Missing Ring, an arcade-type game. Many have searched for the wizard's ancient ring and lived to regret it. Find your way through a maze, solve the mystery, and claim the Missing Ring. For the Apple II; floppy disk, $29.95. Datamost Inc., 8943 Fullbright Ave., Chatsworth, CA 91311.

Money Tool, a money-management program that provides a complete report of your spending pattern. It allows allocation of funds for fixed expenses, semi-fixed costs, and determines how much is left for discretionary purchases. For the Apple II Plus; floppy disk, $59.95. Howard W. Sams & Co. Inc. (see address above).

Music Games, a package of twelve colorful games useful in mastering the art of music by training students of all ages to recognize musical notes and rhythms both visually and audibly. For the Apple II Plus; floppy disk, $39.95. Howard W. Sams & Co. Inc. (see address above).

The Pascal Toolkit, a utility package that contains a character generator, an image-creation utility, DOS-to-Pascal conversion in both text and pictures, and a new library unit called Grafixstuff. For the Apple II, II Plus, and IIe; floppy disk, $24.95. Wize Buys, POB 1588, Orem, UT 84057.

Pinball Paradise, four pinball-simulation games. For the Apple; floppy disk, $24.95. Golden Knight Software, 11 Lark Lane, Huntington, CT 06484.

Pinball Paradise II, four different pinball-simulation games. For the Apple; floppy disk, $24.95. Golden Knight Software (see address above).

SAUCE, this high-level programming language allows you to run applications that result in increased productivity. For the Apple II Plus and IIe; floppy disk, $400. Sonora Enterprises, POB 4841, Albuquerque, NM 87196.

Scoreboard. A program that records and displays game scores in large graphic characters on the screen. It can display up to eight names of players who are tied or winning. For the Apple II Plus and IIe; floppy disk, $17.95. Rosecom Computer Products, 604 East Arcadia, Peoria, IL 61603.

Spectre, an arcade-type game. While you're lost in outer space, the Questers, the most vicious life form in the universe, are swarming through space ports seeking to destroy you. Think and act quickly if you hope to survive. For the Apple II or II Plus; floppy disk, $29.95. Datamost (see address above).

Star Maze, an arcade-type game in which you must find

the 9 power jewels in each of 16 levels of the maze and return them to your mothership. Avoid or destroy alien ships with bullets or a limited supply of antimatter bombs. For the Apple II; floppy disk, $34.95. Sir-tech Software Inc., 6 Main St., Ogdensburg, NY 13669.

Atari

A.E., an arcade-type game. Squadrons of menacing sting rays are attacking you and eluding your missiles. You will be doomed unless you can chase them into outer space. Requires a joystick. For the Atari 400/800; floppy disk, $34.95. Broderbund Software Inc., 1938 Fourth St., San Rafael, CA 94901.

Crisis Mountain, an arcade-type game. Your mission is to defuse bombs planted by terrorists in the treacherous caverns of an active volcano. To reach them you must go through a maze avoiding boulders, tunnels, lava, and a radioactive bat. Requires a joystick. For the Atari 400/800; floppy disk, $34.95. Synergistic Software, Suite 201, 830 North Riverside Dr., Renton, WA 98055.

G.I. Joe Cobra Strike, an arcade-type game. The headquarters of the Special Mission Forces is under siege by the archenemy, Cobra, an evil organization determined to take over the world. To defend the camp, you must destroy the cobra. For the Atari 2600; cartridge, $30. Parker Brothers, 50 Dunham Rd., Beverly, MA 01915.

No Escape, an arcade-type game. Jason has taken the Golden Fleece and angered the gods of Olympus. Imprisoned in the Temple of Aphrodite and armed with stones and magic bricks, Jason must fight frenzied Furies. For the Atari 2600; cartridge, $29.95. Imagic, 981 University Ave., Los Gatos, CA 95030.

Repton, an arcade-type game. As you take over the controls of the Star Fighter *Armageddon*, the Quarriors are attacking Repton. Stop them using your laser gun, nuke bombs, radar screen, and energy shield. For the Atari 800 and 1200; floppy disk, $39.95. Sirius Software Inc., 10364 Rockingham Dr., Sacramento, CA 95827.

Sky Blazer, an arcade-type game. You'll need the WWIII jet to clear away radar stations, avoid supersonic tanks, find and destroy ICBM installations, and escape missiles as you make your final bomb run on the Bungeling Empire headquarters. Requires a joystick. For the Atari 400/800; floppy disk, $31.95. Broderbund Software Inc. (see address above).

Sky Skipper, an arcade-type game. The sky's the limit for young players as they control a dive-bombing plane on a daredevil rescue mission. Pilots come to the aid of helpless kittens, turtles, ducks, and rabbits held captive by gorillas. For the Atari 2600; cartridge, $30. Parker Brothers (see address above).

Strawberry Shortcake, an arcade-type game for ages 4 to 7. The Purple Pieman cast an evil spell on Strawberry Shortcake and all her friends. Now everyone has a body that's all mixed up. See if you can put Strawberryland characters back together again. For the Atari 2600; cartridge, $30. Parker Brothers (see address above).

Telengard, an arcade-type game. You control a character who must descend to the depths of Telengard and battle monsters. Gain strength by finding enchanted items. Six levels of play. For the Atari 800; cassette, $23. The Avalon Hill Game Co., 4517 Harford Rd., Baltimore, MD 21214.

Commodore

Bartender's Friend, a bar-recipe guide and liquor term-definer program. This automated program contains hundreds of recipes and bar terms. For the Commodore 64; cassette, $9.95. Raymond L. Reynolds, 384 Hyacinth St., Fall River, MA 02720.

Practicalc, an electronic-spreadsheet program that lets you perform bookkeeping operations, several mathematical functions, and projections. You can enter titles and numerical data into rows and columns. For the Commodore VIC-20; cassette, $39.95. Micro Software International Inc., 50 Teed Dr., Randolph, MA 02368.

Programmable Characters Package. With these three programs, Single-Edit, Multi-Edit, and Data Generator, programmable characters can be designed either singly or in up to 5 by 5 blocks. Requires a joystick. For the Commodore VIC-20; cassette, $14.95. Sunshine Software, POB 473, Portage, MI 49081.

Telengard, an arcade-type game (see description under Atari). For the Commodore 64 and PET 2001; cassette, $23. The Avalon Hill Game Co., 4517 Harford Rd., Baltimore, MD 21214.

IBM Personal Computer

Cross Reference Utility, a programming aid that provides the BASIC programmer with a complete reference listing of variables within a BASIC program. You can review, analyze, and modify the program to maximum capability. For the IBM Personal Computer; floppy disk, $29.95. Prentice-Hall Software Inc., Route 9W, Englewood Cliffs, NJ 07632.

Night Mission Pinball, a simulated pinball game in which your plane is in a World War II night bombing run. Use up to four balls and flippers to score in a playfield with five bumpers, seven targets, nine rollovers, and two spinners. For the IBM Personal Computer; floppy disk, $39.95. Sublogic Corp., 713 Edgebrook Dr., Champaign, IL 61820.

PL/I-86, an implementation of the PL/I language based on the ANSI General Purpose Subset. The package includes a reference manual, programming guide, and command summary. For the IBM Personal Computer; floppy disk, $750. Digital Research, POB 579, 160 Central Ave., Pacific Grove, CA 93950.

Peachtext 5000, a package that combines word processing, financial planning, and simple database management features for a complete personal-productivity system. It incorporates Random House Electronic Thesaurus, the Peachcalc electronic spreadsheet, and more. For the IBM Personal Computer; floppy disk, $395. Peachtree Software Inc., 8th Floor, 3445 Peachtree Rd. NE, Atlanta, GA 30326.

Pie:Writer, a word-processing package that includes split-screen editing, full use of the keyboard, and customized function-key support. This program can process two files at once and provides virtual-file storage. For the IBM Personal Computer; floppy disk, $199.95. Hayden Software Co., 600 Suffolk St., Lowell, MA 01853.

The Screen Generator, a screen-management program that provides a generalized method to design, build, and change screens in minutes for computer applications. It can be used to build screens "outside" of the application because all screen information is stored and updated on libraries external to your programs. For the IBM Personal Computer; floppy disk, $125. K & S Systems, POB 643, Drexel Hill, PA 19026.

SmarTerm/PC, a terminal-emulator program that lets your IBM Personal Computer function like a Digital Equipment Corporation VT100, VT101, VT102, or VT52 terminal. It implements features such as setup mode, character attributes, line and character insert and delete, and full local printer support. For the IBM Personal Computer; floppy disk, $150. Persoft Inc., 2740 Ski Lane, Madison, WI 53713.

Stock Portfolio Reporter, a program that gives investors current information on as many as 100 stock accounts. Market prices can be updated automatically from log-on to log-off using Dow Jones News/Retrieval. For the IBM Personal Computer; floppy disk, $179. Micro Investment Systems Inc., POB 8599, Atlanta, GA 30306.

TRS-80

Assignment: Europe, a travel-simulation game in which 10 players receive different travel assignments and must find the most efficient way to complete them using different communications between various cities in Europe. For the TRS-80 Models I and III; floppy disk, $24.75. Triangle Software, POB 58182, Raleigh, NC 27658.

Banking, an investing game in which you try to generate the largest amount of income through the use of competitive marketing, careful expansion, and a well-chosen advertisement budget. For the TRS-80 Models I and III; floppy disk, $29.75. Triangle Software (see address above).

Draw, a graphics and text program that lets you draw designs on the screen using cursor control keys, special commands, and automatic drawing routines. You can save displays on disk or in your own programs. For the TRS-80 Model III; floppy disk, $29.95. Lichen Software, 6603 North Lee St., Spokane, WA 99207.

Fraction Math Quiz, a math-drill program that contains five levels of problems in fraction operations. Intuitive reasoning skills are encouraged by the multiple-choice format for students ranging from elementary to high school. For the TRS-80 Color Computer, cassette, $14.95. Creative Technical Consultants, POB 652, Cedar Crest, NM 87008.

Kwikdraw, a fast graphics and text program written in machine code that lets you move, duplicate, and erase your designs of figures and/or text. Save and load displays in BASIC, ASCII, or object codes. For the TRS-80 Model III; floppy disk, $74.95. Lichen Software (see address above).

Music**, a musical program that uses four simultaneous notes without additional hardware. This program includes two voices you select, tempo adjust, functional display of note position, more than four octaves, reserve storage for 2000 notes, and direct play from the keyboard. For the TRS-80 Color Computer; cassette, $19.95. Saffron Software, 5306 Birch Grove Dr., San Jose, CA 95123.

Propack, a machine-language package that gives you simple and foolproof access to your Profile files from a BASIC program. Assign a string array for each file to be used and address your files by logical record number or index keys. For the TRS-80 Model III; floppy disk, $75. The Small Computer Co., Suite 1200, 230 West 41st St., New York, NY 10036.

Prosort, a data-organizer program that sorts data into almost any order for print, inquiry, and Superscripsit selection operations. The program, for use with Profile III+, includes five print indexes and an inquiry index. For the TRS-80 Model III; floppy disk, $150. The Small Computer Co. (see address above).

Telengard, an arcade-type game (see description under Atari). For the TRS-80 Models I and III; cassette, $23. The Avalon Hill Game Co., 4517 Harford Rd., Baltimore, MD 21214.

Other Computers

Clip, a CP/M utilities package that allows the user to store command files, edit lines and files, and use a built-in calculator program. It contains over 50 commands. For CP/M-based systems; floppy disk, $49.95. Thoughtware Inc., Suite 4, 2450 East Speedway, Tucson, AZ 85719.

HexPrintR, a utility program for Wordstar that allows you to take advantage of the full capabilities of your printer. You can send any number of any type of characters to your printer from any place in your text. For the Osborne 1; floppy disk, $39. C.I. Software & Computer Products, 1380 Garnet Ave., E149, San Diego, CA 92109.

Hidden Palace. You assume the role of a treasure hunter trying to find a priceless vase amidst several dangers in an ancient jungle palace. For the Texas Instruments 99/4A; cassette, $14.95. Innovative Data Co., 1041 Dan Kuykendall Cv., Memphis, TN 38111.

War Boats, a game in which you place your boats on a 10 by 10 grid and try to guess the positions of your opponent's boats. Sink boats with shots that are displayed graphically on the screen. For the Timex/Sinclair 1000; cassette, $2.99. Computer Heroes, 1961 Dunn Rd., East Liverpool, OH 43920.■

This is a list of software packages that have been received by BYTE Publications during the past month. The list is correct to the best of our knowledge, but it is not meant to be a full description of the product or the forms in which the product is available. In particular, some packages may be sold for several machines or in both cassette and floppy-disk format; the product listed here is the version received by BYTE Publications.

This is an all-inclusive list that makes no comment on the quality or usefulness of the software listed. We regret that we cannot review every software package we receive. Instead, this list is meant to be a monthly acknowledgment of these packages and the companies that sent them. All software received is considered to be on loan to BYTE and is returned to the manufacturer after a set period of time. Companies sending software packages should be sure to include the list price of the packages and (where appropriate) the alternate forms in which they are available.

Event Queue

August 1983

August

Engineering Summer Conferences, Chrysler Center for Continuing Engineering Education, North Campus, University of Michigan, Ann Arbor. Two of the seven courses offered this month are "Software Design Techniques and Ada" and "Operations Research and the Management Sciences: Methods and Tools." The fees are $600 and $675, respectively. For course outlines and registration details, contact Engineering Summer Conferences, 200 Chrysler Center, North Campus, University of Michigan, Ann Arbor, MI 48109, (313) 764-8490.

August

Unix Seminar, various sites throughout Canada. This three-day seminar serves as an introduction to the Unix operating system. It includes discussions of standard user-level programs and commands for file manipulation, word processing, and programming. The pros and cons of Unix for specific applications and such application areas as database and real-time processing, data communication, and office automation are explored. The fee is $645. For information, contact the Center for Advanced Professional Education Inc., 11928 North Earlham, Orange, CA 92669, (714) 633-9280.

August-September

How to Document a Computer System as It Is Being Developed, various sites throughout the U.S. and Canada. This one-day workshop presents a series of simple procedures that can be followed in recording the results of each task performed during the development of a computer system. The fee is $155. Contact Technical Communications Associates, Suite 210, 1250 Oakmead Parkway, Sunnyvale, CA 94086, (800) 277-3800, ext. 977; in California, (800) 792-0990, ext. 977.

August-September

Local Networks: Promise Into Practice, various sites throughout the U.S. This two-day seminar will focus on the criteria for designing and choosing local networks and the experiences that users have had in selecting and installing local networks. The fee is $595. Full details are available from Architecture Technology Corp., POB 24344, Minneapolis, MN 55424, (612) 935-2035.

August-October

Repair of Microcomputer-based Equipment, various sites throughout the U.S. and Canada. This lecture/laboratory sequence is intended for field-service personnel,engineers, and technical writers. The seminar describes general servicing practices that are applied to the subsystems of any microprocessor family. For further information, contact the Registrar, Testek Consultants Inc., 1000 North Patton St., Arlington Heights, IL 60004, (312) 577-2134.

August-November

Applying the New Tools for Profit and Cash Flow Planning: Graphics and Personal Computers, various sites throughout the U.S. This two-day course is designed to help certified public accountants improve and expand management advisory services by using new graphics tools to improve managers' understanding and use of financial planning. A special type of graph designed for financial planning and decision making will be featured. Fees range from $225 to $295. For more information on the course, contact the Purcell Letter on Graphics for Management, POB 06008, Columbus, OH 43206, (614) 444-6571. For a course schedule and registration details, contact Matthew Malok, American Institute of Certified Public Accountants, 1211 Avenue of the Americas, New York, NY 10036, (212) 575-3848.

August-December

IEEE Conferences and Meetings, various sites around the world. The Institute for Electrical and Electronics Engineers (IEEE) sponsors conferences, meetings, and workshops covering high-technology issues. For details, contact the IEEE Computer Society, Suite 300, 1109 Spring St., Silver Spring, MD 20910, (301) 589-8142.

August-December

Intensive Two-Day Seminars for Professional Development, Worcester Polytechnic Institute, Boston metropolitan area, and Hartford and Stamford, CT. Among the seminars being offered are "The Engineer as Manager," "Inventory Control: Using Computers," and "Fundamentals of Data Processing." For in-house seminar information, call Robert J. Hall at (617) 793-5574. For a seminar bulletin and registration information, contact Ginny Bazarian, Office of Continuing Education, Higgins House, Worcester Polytechnic Institute, Worcester, MA 01609, (617) 793-5517.

August-December

Systems Development Documentation: Forms Method, various sites throughout the U.S. and Canada. This one-day seminar is designed for data-processing managers, project leaders, programmers, and technical writers. Topics to be covered include system design documentation, format and style guidelines, and options for end-document publication. The course fee is $155, which includes all materials. In-company presentations are available for groups of 10 or more. For details, contact Technical Communications Associates Inc., 1250 Oakmead Parkway #210, Sunnyvale, CA 94086, (800) 227-3800, ext. 977; in California, (800) 792-0990, ext. 977, or (408) 737-2665.

August 10-12

Microcomputers and High Technology in Vocational Education Conference, Concourse Hotel, Madison, WI. Beginning and advanced classes on microcomputers, presentations on vocational education programs, and software exhibits will be featured. For details, contact Judy Rodenstein or Roger Lambert, Vocational Studies Center, 964 Educational Sciences Building, University of Wisconsin, 1025 West Johnson St., Madison, WI 53706, (608) 263-4367 or 263-2704.

August 11-13

Personal Computer Interfacing and Scientific Instrument Automation, Williamsburg, VA. This workshop provides each participant with hands-on experience in wiring and testing interfaces. The fee is $395. Call or write Dr. Linda Leffel, C.E.C., Virginia Polytechnic Institute and State University, Blacksburg, VA 24061, (703) 961-4848.

August 15-17

Small Computers in Criminal Justice Agencies, Cincinnati, OH. This conference is designed to help beginners un-

derstand and appreciate the use and application of microcomputers in criminal justice agencies. The fee is $285, which includes luncheons, continuing education units, and materials. Contact Carol Strand, Anderson Publishing Co., 646 Main St., POB 1576, Cincinnati, OH 45201, (800) 543-0883; in Ohio, (800) 582-7295.

August 15-19

Advanced C Topics Seminar, New York, NY. Practical topics for C programmers are covered in this course offered by Plum Hall Inc. Areas of interest include portability, efficiency, readability, debugging, packaging, and interfacing. For further details, contact Joan Hall, Plum Hall Inc., 1 Spruce Ave., Cardiff, NJ 08232, (609) 927-3770.

August 15-19

Managing People, Productivity, Projects, Profitability, Worcester Polytechnic Institute, Worcester, MA. This course covers the entire management spectrum from communications and negotiating to controlling particular projects. The fee is $975. Contact Kathy Shaw, Office of Continuing Professional Education, Worcester Polytechic Institute, Worcester, MA 01609, (617) 793-5517.

August 16-17

Polymer Materials for Electronic Applications, Hyatt Rickey's Hotel, Palo Alto, CA. The fee for this short course is $395. For information, contact Continuing Education in Engineering, Department 622N, University of California Extension, 2223 Fulton St., Berkeley, CA 94720, (415) 642-4151.

August 16-19

Landsat: Sensor Design & Operation, University of California, Santa Barbara. This course is intended for users of remote-sensor data, including geographers, geologists, and engineers. It covers such topics as sensor requirements and user needs, sensor-design principles and tradeoffs, and multispectral-scanner and thematic-mapper operation. It's cosponsored by the Santa Barbara Research Center and the National Oceanic and Atmospheric Administration. The fee is $450. For a brochure, contact J. Weisman, University of California Extension, Santa Barbara, CA 93106, (805) 961-3697.

August 17-19

SNA and Teleprocessing Access Methods, Hyatt Regency, New Brunswick, NJ. This course traces the evolution of data-communications software. Topic areas include host-control software requirements and SNA (system network architecture) concepts, protocols, and implementations. The registration fee is $645. Full details are available from the Center for Advanced Professional Education, 11928 North Earlham, Orange, CA 92669, (714) 633-9280.

August 18-19

Computer Literacy for Lawyers, Denver, CO. This seminar is intended to introduce attorneys to basic computer concepts and their application to the practice of law. Topics will include the specific uses, costs, and benefits of using computers in legal practice. The fee is $550, which includes reference materials. Group discounts are available. For further information, contact Kathryn Mann, Center for Legal Studies, 1926 Arch St., Philadelphia, PA 19103, (215) 732-6999.

August 19-21

The Second Annual National Heath Users Group (HUG) Conference, Hyatt Regency O'Hare, Chicago, IL. A products display and seminars on topics of interest to Heath/Zenith users will be featured. Contact HUG, Hilltop Rd., St. Joseph, MI 49085, (616) 982-3463.

August 20

The First Annual Ham & Chip Flea Market, La Salle College, Philadelphia, PA. Computer software, hardware, ham radio, electronics, and sound equipment will be featured. Contact the Philadelphia Area Computer Society, POB 1954, Philadelphia, PA 19105, (215) 951-1255.

August 21-26

The Fourth World Congress on Medical Informatics–MEDINFO 83, RAI International Congress and Exhibition Centre, Amsterdam, The Netherlands. This event combines scientific, technical, and social programs. Approximately 300 scientific papers will be presented on health and hospital systems, clinical laboratory systems, imaging, nursing applications, and preventive and occupational care. Demonstrations, product exhibits, film and video sessions, tours, workshops, and special-interest meetings will be held. The conference language will be English. Further details are available from the MEDINFO 83 Congress Office, Enschedepad 41-43, NL-1324 GB Almere-Stad, The Netherlands.

August 22

The Revolution in Telecommunications Technologies: Integrating Telecommunications Into Corporate Strategy, Worcester, MA. This executive briefing outlines specific ways to reduce communications costs and offers techniques for developing a basis of integration and planning among various parties within an organization. The fee is $690. Information on in-house executive presentations is available from Robert J. Hall at (617) 793-5574. For complete details, contact Ms. Ginny Bazarian, Office of Continuing Education, Worcester Polytechnic Institute, Worcester, MA 01609, (617) 793-5517.

August 22-26

The National Conference on Artificial Intelligence–AAAI-83, Washington Hilton Hotel, Washington, DC. This conference is sponsored by the American Association for Artificial Intelligence (AAAI). Displays of computer hardware and software, formal presentations, and the Fredkin Chess Prize Competition highlight this conference. Contact Claudia Mazzetti, AAAI, 445 Burgess Dr., Menlo Park, CA 94025, (415) 328-3123.

August 23

The Revolution in Telecommunications Technologies: Integrating Telecommunications Into Corporate Strategy, New York, NY. For details, see August 22.

August 23-24

Indycon '83, Convention Center, Indianapolis, IN. This conference and exhibition features more than 35 technical sessions and 300 exhibition booths devoted to microcomputers and electronic components. Contact Indycon '83, POB 40312, Indianapolis, IN 46260, (317) 875-7711.

August 24-26

SNA and Teleprocessing Methods, Marriott Hotel, Portland, OR. For details, see August 17-19.

August 25-26

Fundamentals of Data Processing for the Non Data-Processing Executive, Washington, DC. Major topics to be covered include computer technology, the functions of an information system, the development of applications

software, and the costs and benefits of information systems. This seminar is presented by the Wharton School of the University of Pennsylvania. The fee is $795. In-house programs are available. For details, contact Wharton FDP Seminar, Registrar-Processing Center, 30-30 Borden Ave., Long Island City, NY 11101, (212) 392-9441.

August 26-28

Computers for Farm and Family, St. Paul, MN. This seminar and trade show, organized by the Minnesota Agricultural Extension Service and *The Farmer/Dakota Farmer* magazine, will be held in conjunction with the Minnesota State Fair. Featured will be exhibits, presentations, and educational sessions for experienced computer users and the novice farm and home computer user. Contact Sandra J. Becker, Office of Special Programs-XY, 405 Coffey Hall, University of Minnesota, 1420 Eckles Ave., St. Paul, MN 55108, (612) 373-0725.

August 26-28

The First IBM PC Faire, Civic Auditorium and Brooks Hall, San Francisco, CA. The focus of this fair will be on hardware, software, and applications for the IBM Personal Computer. Technical conferences, formal papers, product expositions, and special-interest group meetings will be held. For details, contact IBM PC Faire, 345 Swett Rd., Woodside, CA 94062, (415) 851-7077.

August 26-September 3

The International Telecommunications, Scientific, and Technical Expoconference-Telexpo China 1983, Foreign Trade Center, Guangzhou (Canton), Jiangxi Province, People's Republic of China. The theme of this communications-equipment show is "An Integrated Telecommunications System for China." Displays will include aerospace equipment, computers, and peripherals. Additional information is available from AVP Expositions Co. Ltd., Suite 13, 13/F, Block A, Wahkai Industrial Center, 221 Texaco Rd., NT Hong Kong; tel: 0-239003; Telex: 40725 AVPEX HX.

August 28

The Tenth Annual Hamfest/Computerfest, Hershey, PA. This event, sponsored by the Central Pennsylvania Repeater Association, will feature a large indoor dealer and flea market area. For details, contact Timothy R. Fanus, WB3DNA, 6140 Chambers Hill Rd., Harrisburg, PA 17111, (717) 564-0897 between noon and 8 p.m.

August 29-31

DBMS-M[4] Systems, Washington, DC. For details, contact the Continuing Education Institute, Oliver's Carriage House, 5410 Leaf Treader Way, Columbia, MD 21044, (301) 596-0111; on the West Coast, (213) 824-9545.

August 29-31

Printed Circuit Fabrication, Red Lion Inn, San Jose, CA. This technical seminar probes a variety of issues relating to printed-circuit board manufacturing. It's sponsored by PMS Industries, publisher of *Printed Circuit Fabrication* magazine. The cost for the complete program is $300. The per day rate is $125. Contact Mike Brody, Printed Circuit Fabrication/West Coast, Suite 105S, 4010 Moorpark Ave., San Jose, CA 95117, (408) 246-5575.

August 30

Meeting Internal Audit Objectives with Statistical Sampling—Tests of Compliance, Los Angeles, CA. Designed as an introduction to or refresher course in applying attribute sampling to compliance tests of internal controls, this seminar addresses the cost-effectiveness and techniques of statistical sampling. Contact Joe Bartley, Coopers & Lybrand, National Professional Education, 80 Park Plaza, Newark, NJ 07102, (201) 621-5715.

September 1983

September-October

Computer-assisted Manual Writing, various sites throughout the U.S. This one-day seminar is designed to teach attendees how to produce good software manuals. The sponsor will demonstrate a software package for automated documentation development called Manual Maker. The fee is $195. For further information, contact Promptdoc, 833 West Colorado Ave., Colorado Springs, CO 80905, (303) 471-9875.

September-November

Computer Showcase Expos, various sites throughout the U.S. This popular show will bring together hardware and software manufacturers, dealers, and consumers of small computer systems. For details, contact The Interface Group, 160 Speen St., POB 927, Framingham, MA 01701, (800) 225-4620; in Massachusetts, (617) 879-4502.

September-November

Courses from Integrated Computer Systems, various sites throughout the U.S. Course titles include "Hands-On Pascal Workshop," "Structured Design and Programming," "Software Project Management," and "Defining Software Requirements, Specifications, and Tests." Fees range from $695 to $845. For information, contact Ruth Dordick, Integrated Computer Systems, 3304 Pico Blvd., POB 5339, Santa Monica, CA 90405, (213) 450-2060.

September-December

Software Workshops in MMSFORTH, Boston metropolitan area. These workshops are public versions of the professional training Miller Microcomputer Services (MMS) offers to client companies in support of the MMSFORTH product line. A variety of topics and skill levels are covered. Full details are available from Miller Microcomputer Services, 61 Lake Shore Rd., Natick, MA 01760, (617) 653-6136.

September-January 1984

Technology Opportunity Conference, various sites throughout the U.S. This conference series focuses on the convergence of optical-storage, videodisc, and computer technologies. For full details, contact Technology Opportunity Conference, POB 14817, San Francisco, CA 94114, (415) 626-1133.

September 1-2

The First Meeting of the European Chapter of the Association for Computational Linguistics, University of Pisa, Italy. A variety of formal papers will address such topics as syntax, parsing, and language generation; speech analysis and synthesis; and software tools and programming languages for computational linguistics. Contact Harold Somers, Centre for Computational Linguistics, UMIST, POB 88, Manchester M60 1QD, England.

September 6-10

Asian International Electricals, Electronics, and Communications Exhibition '83-Elecom Asia '83, Stadium Negara, Kuala Lumpur, Malaysia. This trade show serves as

a showcase for a wide spectrum of high-technology equipment and materials. Government ministers from the five ASEAN (Association of Southeast Asian Nations) countries (Indonesia, Malaysia, Philippines, Singapore, and Thailand) will attend. For details, contact Technology Marketing Analysis Corp., Suite 428, 680 Beach St., San Francisco, CA 94109, (415) 474-3000. In Malaysia, contact ISE Management (M) SDN BHD, 3-A Jalan SS 24/8, Taman Megah, Petaling Jaya, Selangor, Malaysia; tel: 749377; Telex: MA 37204 AKMISE.

September 6-10
The 1983 AAMI Regional Meeting, Detroit, MI. The Association for the Advancement of Medical Instrumentation (AAMI) has tailored this program of tutorial courses, technical service seminars, and product displays to address the regional needs of the Detroit area. Contact the AAMI, 1901 North Fort Myer Dr., Arlington, VA 22209, (703) 525-4890.

September 8-10
Personal Computer Interfacing and Scientific Instrument Automation, Greensboro, NC. For details, see August 11-13.

September 11-14
The American Data Services (ADS) Users Seminar, Marriott Resort, Lincolnshire, IL. This seminar focuses on the ADS inventory-management system. A procedural cost system for hospital departments will be introduced. Contact Sharon Spencer, American Data Services, Suite 210, 900 North Shore Dr., Lake Bluff, IL 60044, (312) 295-6850.

September 13-15
AUTOFACT Europe Conference and Exhibition, Palexpo Exhibition Center, Geneva, Switzerland. This conference, cosponsored by the Society of Manufacturing Engineers (SME) and the Institution of Production Engineers of London, England, will focus on the technologies of automated and computer-integrated manufacturing for European production. Technical sessions will explore both theory and applications strategies. A complementary products display will be featured. Contact the Society of Manufacturing Engineers, Public Relations Department, One SME Dr., POB 930, Dearborn, MI 48121, (313) 271-0777.

September 13-15
Midcon/83 and **Mini/Micro-Midwest/83**, Chicago, IL. Topics on the professional program include computer simulation, energy management, laser applications, and printed-circuit-board technology. An exhibit area is planned. For further information, contact Electronic Conventions Inc., 8110 Airport Blvd., Los Angeles, CA 90045, (213) 772-2965.

September 13-15
Peripherals '83, Moscone Center, San Francisco, CA. Full details are available from Cahners Exposition Group, Cahners Plaza, 1350 East Touhy Ave., POB 5060, Des Plaines, IL 60018, (312) 299-9311.

September 14-16
Euromicro '83, Madrid, Spain. This ninth annual symposium will cover microprocessing and programming. Speeches will address economic and social aspects of microprocessors and trends in VLSI (very large-scale integration) technology. Tutorials, seminars, and an exhibition are planned. The highlight of this event is the Euromouse contest, in which mechanical mice from around the world race around a maze. A complete program is available from Euromicro, TH Twente, POB 217, Department INF, Room A312, 7500 AE Enschede, The Netherlands; tel: (31) (53) 338799; Telex: 44200 Thes.

September 15-16
Ethernet-type Local Networks, San Francisco, CA. This is the third program in the four-part Architecture Technology Corporation 1983 Forum Series. This program will bring together manufacturers and users of local network schemes to exchange information in an informal setting. The format includes presentations, panel discussions, and a technological summary. The fee is $395. For further information, contact the Architecture Technology Corp., POB 24344, Minneapolis, MN 55424, (612) 935-2035.

September 15-16
The Second Annual Indiana Computer Expo, Convention Center, Indianapolis, IN. This exposition is designed for business end-users interested in mini- and microcomputers, software, word processing, graphics, services, and peripherals. Contact Ernie Kerns & Associates, Trade Show Department, Suite 201, 2555 East 55th Place, Indianapolis, IN 46220, (317) 259-8111.

September 16-18
The First Annual Heart of Texas Computer Show, Convention Center, San Antonio, TX. This show will emphasize small-business systems for financial and inventory control, agribusiness, education, and personal needs. More than 200 hardware, software, and peripheral vendors will display their wares. Show details are available from Robin G. Mann, Heart of Texas, POB 12094, San Antonio, TX 78212, (512) 226-4636.

September 16-18
Great Southern Computer & Electronics Show '83, Memorial Coliseum, Jacksonville, FL. Computers, electronics, and information services will be featured. Contact Great Southern Computer & Electronics Shows, POB 655, Jacksonville, FL 32201, (904) 384-6440.

September 19-21
The Third Annual Videodisc Conference, New York Hilton Hotel, New York, NY. For details, contact Meckler Publishing, 520 Riverside Ave., Westport, CT 06880, (203) 226-6967.

September 19-23
The Ninth World Computer Congress - IFIP '83, Paris, France. This event, sponsored by the International Federation for Information Processing (IFIP), is held in conjunction with SICOB, the major French computer exposition. Formal papers and panel sessions will cover such areas as computer hardware and software, theoretical foundations of information processing, networks, and communications. For full program details, contact the U.S. Committee for IFIP '83, Dorn Computer Consultants, 25 East 86th St., New York, NY 10028, (212) 427-7460.

September 20-21
Data Storage 83, Marriott Hotel, Santa Clara, CA. This international forum covers industry issues and areas of change in data-storage equipment and applications. The fee is $850. Contact Cartlidge & Associates Inc., Suite 205, 4030 Moorpark Ave., San Jose, CA 95117, (408) 554-6644.

September 20-22
Caribbean Informatics '83, San Juan, Puerto Rico. This is the first major international exhibition and conference to be held in the Caribbean

area. For further details, contact Informatics '83, Suite 219, 3421 M St. NW, Washington, DC 20007, (703) 920-9595.

September 21-22

Business-Expo, Boston, MA. This exposition serves as a showcase for office equipment ranging from computers to coffee machines. More than 20 seminars are presented. Address inquiries to Business-Expo, 702 East Northland Towers, 15565 Northland Dr., Southfield, MI 48075, (313) 569-8280.

September 26-28

Maecon/83, Kansas City, MO. This electronic show and convention explores such topics as aerospace electronics, computer peripherals, laser technology, and personal computing. Contact Electronic Conventions Inc., 8110 Airport Blvd., Los Angeles, CA 90045, (213) 772-2965.

September 26-29

The World of CAD/CAM, Boca Raton Resort Hotel, FL. This seminar provides an overview of how manufacturing will change as the automated factory becomes a reality. It will consist of four one-day presentations in computer-aided engineering, design, manufacturing, and computer-integrated manufacturing. For a brochure, write or call the Center for Manufacturing Technology, 4170 Crossgate Dr., Cincinnati, OH 45236, (513) 791-8801.

September 26-30

Compcon Fall '83, Marriott Crystal Gateway Hotel, Arlington, VA. The theme of this show is "Delivering Computer Power to End Users." It features technical papers and panel sessions that address a variety of computer and computer-network issues. It is sponsored by the Institute of Electrical and Electronics Engineers (IEEE) Computer Society. For more information, contact Compcon Fall '83, POB 639, Silver Spring, MD 20901, (301) 589-8142.

September 26-30

Conference on Networks and Electronic Office Systems, University of Reading, Berkshire, England. This conference will provide a forum for the exchange of information and for discussion of recent and future developments relating to networks and electronic office systems. Further information is available from the Conference Secretariat, Institution of Electronic and Radio Engineers, 99 Gower St., London WC1E 6AZ, England; tel: 01-388 3071; Telex: Instrad London WC1.

September 26-30

Expo Beirut '83, Beirut, Lebanon. This is Lebanon's first international reconstruction/development exposition and conference after eight years of civil war. Topics to be covered include contruction, transportation, communications, agriculture, computer hardware and software, metallurgy, textiles, and automated equipment. Further details are available from Show-Tech International Inc., 950 Third Ave., New York, NY 10022.

September 28-29

Ottawa Computer and Office Automation Show, Civic Centre, Ottawa, Ontario, Canada. For details, contact Industrial Trade Shows of Canada, 20 Butterick Rd., Toronto, Ontario M8W 3Z8, Canada, (416) 252-7791.

September 28-October 2

The Sixth Personal Computer World Show, Barbican Centre, London, England. This show, one of the largest computer shows in Great Britain, is sponsored by *Personal Computer World* magazine. Business, scientific, technical, and educational uses of microcomputing will be featured as well as hobbyist and home-based systems. For information, contact Tim Collins, Montbuild Ltd., 11 Manchester Square, London W1M 5AB, England; tel: 01-486 1951; Telex: 24591.

September 29-October 1

CP/M '83 East, Hynes Auditorium, Boston, MA. For information on this conference and exposition, contact Northeast Expositions Inc., 826 Boylston St., Chestnut Hill, MA 02167, (800) 343-2222; in Massachusetts, (617) 739-2000.

October 1983

October 1

The Third Annual Microcomputers in Education Conference, Dutchess County Community College, Poughkeepsie, NY. Dr. Delores Shanahan, an innovator in the field of special education and computers, will speak at this event sponsored by the Microcomputer Educator Group. Details are available from Dr. Florence Staats, Office of Community Services, Dutchess County Community College, Pendell Rd., Poughkeepsie, NY 12601, (914) 471-4500, ext. 240.

October 2-5

Computer Systems Exposition, MGM Grand Hotel, Las Vegas, NV. This exposition will be held in conjunction with the annual meeting of the National Association of Convenience Stores. Hardware and software will be displayed, and computer consultants will be on hand to answer questions. For details, contact the National Association of Convenience Stores, Suite 809, 5201 Leesburg Pike, Falls Church, VA 22041, (703) 578-1800.

October 2-6

The Annual Meeting of the American Society for Information Science – ASIS-83, Crystal City Hyatt Regency, Arlington, VA. The theme for this meeting is "Productivity in the Information Age." Papers, special-interest sessions, information briefings, an information-science theater, and demonstrations will be featured. Further information is available from Edmond Sawyer, ASIS Headquarters, 1010 Sixteenth St. NW, Washington, DC 20036, (202) 659-3644.

October 4-6

The Southwest Computer Conference, Tulsa, OK. The theme for this conference is "Managing Information Technology in the 80s." Computer hardware and software will be exhibited. Contact the Southwest Computer Conference, POB 950, Norman, OK 73070, (405) 329-3660.

October 6-11

Japan Electronics Show '83, Osaka International Trade Fair Grounds, Osaka, Japan. This show will cover a range of consumer and industrial electronic products and components. For information, contact the Japan Electronics Show Association, 24 Mori Building 11F, 3-23-5, Nishi-Shinbashi, Minato-ku, Tokyo 105, Japan; tel: (03) 433-7751.

October 7-9

Great Southern Computer & Electronics Show '83, Centroplex Expo, Orlando, FL. For details, see September 16-18.

October 8-10

PC '83, Bayside Exposition Center, Boston, MA. This conference and exposition features IBM Personal Computers and compatible equipment. A *seminar program*

will explore IBM PC applications, provide technical information, and offer general sessions designed to show users how to get the most from their IBM. For details, contact Northeast Expositions, 822 Boylston St., Chestnut Hill, MA 02167, (800) 841-7000; in Massachusetts, (617) 739-2000.

October 10-14
Defense Computers-Graphics-DCG '83, Convention Center, Washington, DC. Sessions and tutorials will complement this conference and exposition. For more information, contact DCG '83, Suite 333, 2033 M St. NW, Washington, DC 20036, (202) 775-9556.

October 11-13
Southwest Semiconductor & Electronics Exposition-SSE'83, Civic Plaza Convention Center, Phoenix, AZ. Approximately 200 suppliers of equipment, materials, and services used in the electronics industry will attend this show. A technical conference will be held. Contact Cartlidge & Associates Inc., Suite 205, 4030 Moorpark Ave., San Jose, CA 95117, (408) 554-6644.

October 12-21
The Sixth International Trade Exhibition on Office Organizational Systems, Office Furniture, and Office Aids—Systemotechnika '83, Vassilievsky Ostrov Exhibition Centre, Leningrad, Union of Soviet Socialist Republics. On display will be communications systems, microfilming equipment and systems, data-processing equipment, and computers. Contact Düsseldorfer Messegesellschaft mbH-NOWEA-Central Division—Foreign Fairs, Düsseldorf Exhibition Centre, 4000 Düsseldorf 30, Federal Republic of Germany; tel: (02 11) 45 60-1.

October 13-15
Edutech/East '83, Civic Center, Philadelphia, PA. Formerly called Ed Com, this conference and exposition is designed for educators at all levels. Presentations will address such topics as computer-aided instruction, administrative uses of computers, classroom management, programming, research applications, authoring languages, and literacy. The format includes workshops, seminars, demonstrations, hands-on sessions, discussions, and micro courses. Hardware, software, and publishing companies will exhibit their wares. Contact Carol Houts, Judco Computer Expos Inc., Suite 201, 2629 North Scottsdale Rd., Scottsdale, AZ 85257, (800) 528-2355; in Arizona, (602) 990-1715.

October 14-15
Computers and Reading/Learning Difficulties, Dallas, TX. Workshops, hands-on exhibits, and speakers will explore such topics as using computers in learning disability classrooms and evaluating software. This program is designed for all education levels. For information, contact Frost Conference Management, Department I, 1070 Crows Nest Way, Richmond, CA 94803, (415) 222-1249.

October 14-15
The Fifth Annual FORTH Convention, Hyatt Hotel, Palo Atlo, CA. Hands-on tutorials, exhibits, lectures, and discussions highlight this event. The theme is "FORTH-based Systems—A Look Into the Future." Registration is $5. Full details are available from the FORTH Interest Group, POB 1105, San Carlos, CA 94070, (415) 962-8653.

October 14-16
The UCSD Pascal System Users Society Fall Meeting, Hyatt Regency Crystal City, Washington, DC. Contact the Secretary, USUS, POB 1148, La Jolla, CA 92038.

October 15
NJ-NY-CT Microcomputer Show and Flea Market, Meadowlands Hilton Hotel, New Jersey Sports Complex, East Rutherford, NJ. More than 75 commercial exhibitors and 200 flea-market booths will feature hardware, software, books, magazines, and accessories for all popular computers ranging from Apple to Zenith. Registration is $5 for adults and $2 for children. Contact the Kengore Corp., POB 13, Franklin Park, NJ 08823, (201) 297-2526.

October 16-18
The Fifth Annual Hong Kong Consumer Electronics Show, New World Hotel and Regent Hotel, Hong Kong. For details, contact IBS Trade Fair Ltd., 17th Floor, Tung Sun Commercial Centre, 200 Lockhart Rd., Hong Kong; tel: 5-732388-9; Telex: 63037 HKIBS HX.

October 17-19
The Eighth Conference on Local Computer Networks, Minneapolis, MN. The theme for this conference is "Practical Applications and Issues in Local Computer Networks." Papers and tutorials will address such issues as users' versus manufacturers' needs, public versus private networks, software, and VLSI (very large-scale integration). Contact the IEEE Computer Society, POB 639, Silver Spring, MD 20901.

October 18-20
The Fourteenth Annual International Test Conference, Franklin Plaza Hotel, Philadelphia, PA. For information, contact the Conference Registrar, POB 371, Cedar Knolls, NJ 07927, (201) 267-7120.

October 18-21
The Third Symposium on Microcomputer and Microprocessor Applications-μP '83, Hotel Duna Intercontinental and the Hungarian Academy of Sciences, Budapest, Hungary. The conference language will be English. Full details are available from Mrs. I. Bába, Scientific Society for Telecommunication, POB 451, H-1372 Budapest, Hungary; tel: (36) 1 113-027; Telex: MTESZ 22-5792.

October 19-20
Calgary Computer & Office Automation Show and Conference, Roundup Centre, Calgary, Alberta, Canada. For details, contact Industrial Trade Shows of Canada, 20 Butterick Rd., Toronto, Ontario M8W 3Z8, Canada, (416) 252-7791.

October 19-21
The Fourth Canadian Symposium on Instructional Technology, Westin Hotel, Winnipeg, Manitoba, Canada. This symposium, designed for education and training professionals and those interested in computer-aided learning, will explore the theme "Computer Technologies for Productive Learning." Topics on the agenda include computer awareness and literacy in schools and society, systems technology, and computer-aided training and retraining for business, industry, and government. A products exhibition will be held. Contact Ken Charbonneau, Conference Services Office, National Research Council of Canada, Ottawa, Ontario K1A 0R6, Canada, (613) 993-9009; Telex: 053-3145.

October 19-21
IDATE-The Fifth International Conference, Montpellier, France. The theme for this conference, sponsored by the International Telecom-

munication Union, is "Picture Networks." Topics of interest include network functioning and areas of applications, economics and law relating to the visual media, network languages, and languages on the networks. The conference language is French. For further details, contact Francois Rabaté, Responsable Scientifique, Journées Internationales 1983, IDATE—Bureaux du Polygone, 34000 Montpellier, France; tel: (33—67) 65 48 48; Telex: IDATE 490 290.

October 19-21

The National Software Show, Trade Show Center, San Francisco, CA. Full details are available from Raging Bear Productions Inc., Suite 175, 21 Tamal Vista Dr., Corte Madera, CA 94925, (800) 732-2300; in California, (415) 924-1194.

October 19-21

SIBEC—Info Expo, Palais des Congres, Montreal, Canada. Exhibits related to the computer and office automation industries will be held. An international line-up of speakers has been invited. Contact Informatique Québec (Info Expo) Ltée, 1057 Avenue Laurier Ouest, Outremont, Québec H2V 2L2, Canada, (514) 270-5481; in the Toronto area, call (416) 281-3459.

October 19-22

Percompasia 83-The Second South East Asian Personal Computer Hardware & Software Show & Conference, World Trade Centre, Singapore, Republic of Singapore. This show is devoted to all aspects of personal computing. Further details are available from Overseas Exhibition Services Ltd., 11 Manchester Square, London W1M 5AB, England; tel: 01 486 1951; Telex: 24591.

October 24-26

The Annual Conference of the Association for Computing Machinery-ACM '83, Sheraton Centre Hotel, New York, NY. Exhibits of computer hardware and software and paper sessions will focus on the conference theme, "Extending the Human Resource." The emphasis will be on theory and practices of personal computing. Highlighting the conference will be the the Fourth International Computer Chess Championships. For details, contact Thomas A. D'Auria, Assistant Commissioner, City of New York, Computer Service Center, 11th Floor, 111 8th Ave., New York, NY 10011, (212) 620-5055.

October 25-27

The Andean Informatics '83, Bogota, Colombia, South America. This is the first major international exhibition and confertence to be held in the Andean region. For details, contact Informatics '83, Suite 219, 3421 M St. NW, Washington, DC 20007, (703) 920-9595.

October 25-28

Working Conference on Prototyping, Brussels, Belgium. This conference will focus on the user-oriented development of information systems supported by prototyping. Research and technical papers will be presented. The sponsor is the Commission of the European Communities. For information, contact Reinhard Budde or Heinz Zuellighoven, GMD-IST Postfach 1240, Schloss Birlinghoven, D-5205, St. Augustin 1, West Germany; tel: 02241/14-2440; Telex: 8 89 469 gmd d.

October 26-28

Developing Long-Range Systems Strategies, Sheraton Hotel, Washington, DC. This is part of the George Washington University Systems

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October 28-30

Applefest, Moscone Center, San Francisco, CA. More than 300 displays and booths of Apple computer equipment and accessories will be featured. Seminars, panel discussions, conferences, and workshops will be held. Additional information is available from Northeast Expositions Inc., 822 Boylston St., Chestnut Hill, MA 02167, (800) 343-2222; in Massachusetts, (617) 739-2000.

October 30-November 2

DPMA Baltimore '83, Convention Center and Hyatt Regency Hotel, Baltimore, MD. The theme for this conference, sponsored by the Data Processing Management Association (DPMA), is "Information on the Firing Line." Seminars, workshops, general sessions, and product displays will be featured. Contact Jim Osowski, DPMA International Headquarters, 505 Busse Highway, Park Ridge, IL 60068, (312) 825-8124.

October 31-November 2

The Ninth International Conference on Very Large Databases, Palazzo dei Congressi, Florence, Italy. This conference seeks to identify and encourage the research, development, and applications of database technology. Subjects of interest include database control, modeling and managing unformatted data, and novel environments and applications of database technology. Contact Mario Schkolnick, K 55-281, IBM Research Labs, 5600 Cottle Rd., San Jose, CA 95193, (408) 256-1648. In Italy, Renzo Pinzani, Istituto di Matematica U. Dini, Viale Morgagni, 67/A, 50134 Florence, Italy.

October 31-November 3

International Conference on Computer Design–VLSI in Computers, Rye Town Hilton, Port Chester, NY. This conference will cover the VLSI (very large-scale integration) aspects of the interaction between fabricators and system designers in hardware, software, and reliability in computers. Contact the IEEE Computer Society, POB 639, Silver Spring, MD 20901. ■

BYTE's Bits

Trade List Available

A trade list of nearly 2000 overseas buyers, agents, and distributors of computers and peripherals is available from the Department of Commerce. The list provides company names, addresses, contacts, telephone and Telex numbers, and five-digit SIC (Standard Industrial Classification) codes for potential customers in more than 130 countries. For a copy, send $12 to the U.S. Department of Commerce, Office of Trade Information Services, Room 1320, Washington, DC 20230. Checks should be payable to U.S. Department of Commerce/TL. ■

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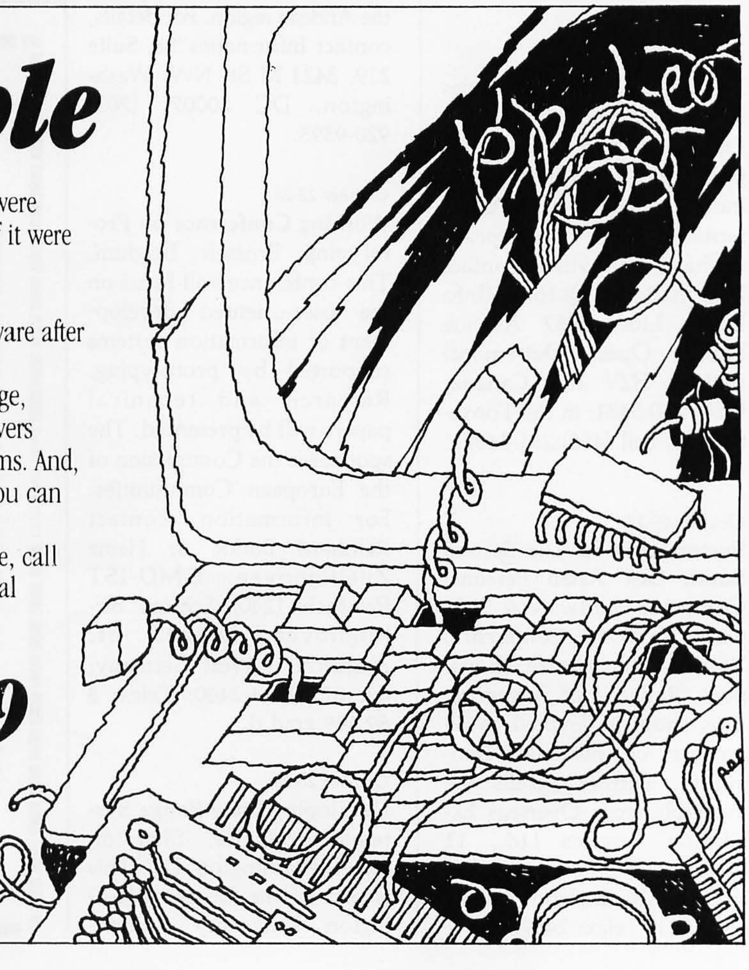
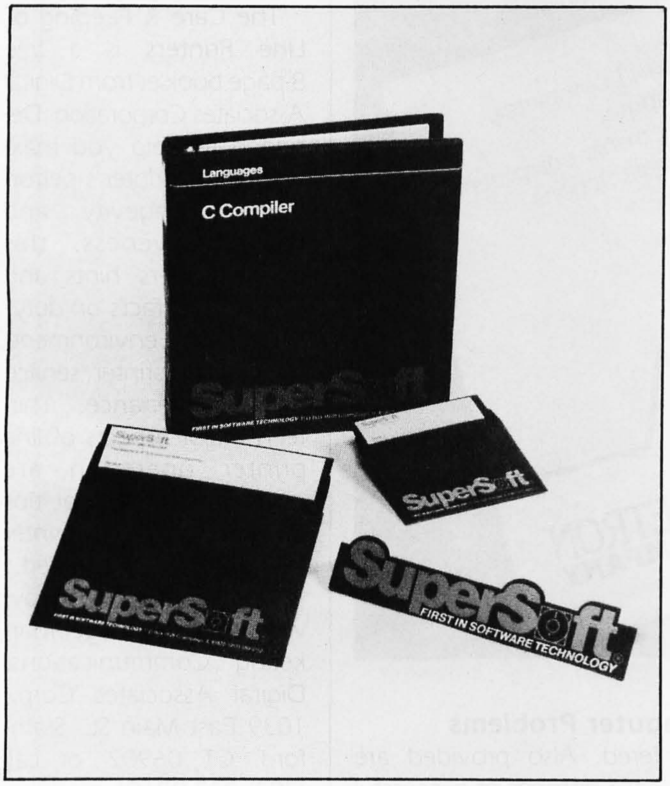


Circle 487 on inquiry card.

What's New?

C-RELATED PRODUCTS



C for CP/M-80, CP/M-86, and MS-DOS

Supersoft has released a version of its Supersoft C compiler for CP/M-80, CP/M-86, and MS-DOS operating systems. This release is syntactically compatible with Unix Version 7 C and supports such features as long-integer and double floating-point functions. Supersoft C is a multipasss compiler that is said to produce highly optimized code. Many Unix-compatible functions are included, which permits transporting source programs betweeen Unix C and Supersoft C with few changes.

An extensive list of library functions is provided with the source code. The Supersoft C compiler costs $500; the CP/M-80 version is $275. For full details, contact Supersoft, 1713 South Neil St., POB 1628, Champaign, IL 61820, (217) 359-2112.

Circle 600 on inquiry card.

Optimizing C Compiler

The Optimizing C86 compiler is designed for professional programmers working with PC-DOS, MS-DOS, or CP/M-86. It permits addressing of 1024K bytes of RAM and provides the option to emit either assembly-language or object-code formats of Microsoft. Optimizing C86 costs $395. A $10 evaluation kit is available. Contact Computer Innovations Inc., Suite J-30X, 10 Mechanic St., Redbank, NJ 07701, (201) 530-0995.

Circle 601 on inquiry card.

C Executive Version 1.3

Version 1.3 of the C Executive has been released by JMI Software. The C Executive allows multiple C and Pascal tasks to run concurrently with inter-task communication, resource coordination, and formatted I/O. The monitor can be stored in ROM. The real-time preemptive scheduler is sensitive to both task priority and system events. Multiple user terminals can be supported with Unix-like characteristics. Other features include clock support, time-based task scheduling, and a portable library of more than 50 routines for memory management, character-string manipulation, and I/O. The complete standard Unix C library is supported as are most standard Pascal procedures and functions.

The C Executive works with a variety of microprocessors, including Intel's 8080/8085 and 8086/8088, the Zilog Z80, Motorola's MC68000 and 6809, and the National Semiconductor NS16032. In binary and source form, the C Executive costs $300. Contact JMI Software Consultants Inc., 1422 Easton Rd., Roslyn, PA 19001, (215) 657-5660.

Circle 602 on inquiry card.

C Programming Guide

The C Programming Guide by Dr. Jack Purdum is a comprehensive tutorial on the fundamentals of the C programming language. Written in an easy-to-understand style, this book offers users at all levels of expertise a learning guide to C. Appendices provide lists of moderately priced commercial C compilers and a summary of the C language's syntax. Example programs and illustrations are included in the presentation.

This 250-page guide costs $17.95 and is available from Que Corp., 7960 Castleway Dr., Indianapolis, IN 46250, (317) 842-7162.

Circle 603 on inquiry card.

PUBLICATIONS

Computer Glossary for Managers

Alan Freedman, an expert in the field of computer literacy, has created a resource work for nontechnical business managers. The Computer Glossary is an illustrated guide through microcomputer jargon. It covers all aspects of computing in a straightforward, plain-talking presentation. Individual copies of the glossary cost $14.95 and are available from Prentice-Hall (POB 500, Englewood Cliffs, NJ 07632). In lots of 10 to 99, each copy costs $12.95. Order in bulk from The Computer Language Co. Inc., 140 West 30th St., New York, NY 10001.

What's New?

Children's Workshop Enters Computer Publishing

The Children's Television Workshop will launch a monthly magazine for children on computers and electronic technology this fall. **Enter** will focus on career opportunities and issues relating to the growth of computer technology in the 1980s. Articles on new developments in computer technology and the influence of computers on a wide range of professions, games, quizzes, puzzles, and simple programming challenges will be among this magazine's monthly features.

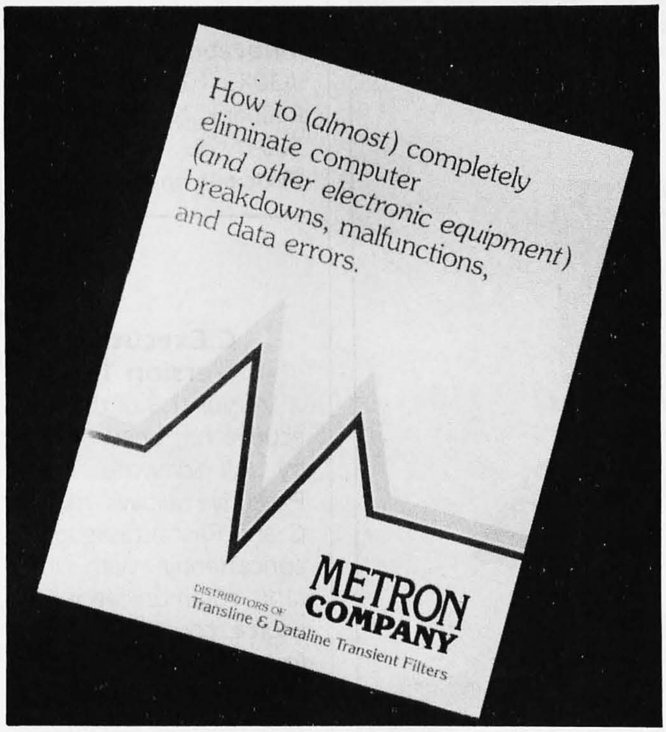
Annual subscriptions will cost $12.95 (10 issues). A classroom bulk rate will be offered. Contact the Children's Television Workshop, One Lincoln Plaza, New York, NY 10023, (212) 595-3456.

Circle 604 on inquiry card.

Information Technology Update

Information Technology On Screen: New Approaches in Viewdata, Teletext and Cable is an update of some of the more important developments taking place or being planned in information technology. This book is a compilation of essays presented at the November 8, 1982 Information Technology On Screen seminar. *It's available for $12 from* the Oryx Press, 2214 North Central, Phoenix, AZ 85004.

Circle 605 on inquiry card.



How to Stop Computer Problems

The introduction of a booklet entitled **How to (Almost) Completely Eliminate Computer Breakdowns and Malfunctions** was announced by the Metron Company. This booklet discusses the most common causes of computer failures and errors. Possible solutions are offered. Also provided are case histories of successful treatments.

The booklet is available free of charge from the Metron Co., Suite 216, 1250 West Dorothy Lane, Kettering, OH 45409, (513) 298-0964.

Circle 606 on inquiry card.

Newsletter for Physicians

A medical newsletter, the **Physician Computer Monthly**, provides information to doctors using microcomputers in their practices. This independent journal covers applications for practice management, patient care, continuing medical education, and communications. It's written in nontechnical language, and it provides hardware updates, software reviews, and news on medical networks.

A one-year subscription is $95. A free sample issue will be provided upon receipt of a request made on letterhead. For full details, write to American Health Consultants, 67 Peachtree Park Dr., Atlanta, GA 30309.

Circle 607 on inquiry card.

Tips on Caring for Printers

The Care & Feeding of Line Printers is a free 8-page booklet from Digital Associates Corporation. Designed to help you maximize your printer's performance, longevity, and cost-effectiveness, this booklet offers hints and little-known facts on duty-cycle, site environment, static, and printer service and maintenance. Thirteen major aspects of line printer operation are covered, and special tips on how to make a printer last longer are presented.

To get your free copy, write to the Manager/Marketing Communications, Digital Associates Corp., 1039 East Main St., Stamford, CT 06902, or call (203) 327-9210.

Circle 608 on inquiry card.

Consumer Buying Guide

Designed to help consumers make an informed decision, **How to Buy a Home Computer** was written by Wes Thomas for the Consumer Electronics Group of the Electronic Industries Association. This 50-page illustrated book provides 11 step-by-step practical questions that embrace a variety of buying considerations. Fill-in-the-blank questions that the consumer should ask about software packages and computers are provided. A budget form for planning expenditures is also included.

What's New?

Retailers can order copies of **How to Buy a Home Computer** at quantity prices beginning at less than $0.25 each. Consumers can obtain a free copy by sending a 5- by 7-inch, self-addressed envelope with $0.54 postage to the Electronic Industries Association, Consumer Electronics Group, POB 19100, Washington, DC 20036, (202) 457-4919.

Circle 609 on inquiry card.

Computer Selection Guide for Managers

A guide for department-level professionals and management information service managers has been produced by Datapro Research Corporation. **How to Select Microcomputers for the Corporate Environment** explains in detail the factors to be considered for properly evaluating desktop computers in the corporate environment, including equipment requirements, software, and support services. This guide addresses key questions involved in selecting a microcomputer, such as policy formulation, vendor evaluation, and software selection. Reports cover the marketplace for computer equipment and software, economic analysis, data security and reliability, training, consulting, installation, and technology. A 10-page "Microcomputer Acquisition Checklist" that aids the user in ensuring that no major selection concerns are overlooked is also included.

How to Select Microcomputers for the Corporate Environment costs $19 per copy. It's available from Datapro Research Corp., 1805 Underwood Blvd., Delran, NJ 08075, (800) 257-9406; in New Jersey, (609) 764-0100.

Circle 610 on inquiry card.

Annual Robotics Directory Released

Technical Database Corporation has released its **1983 Robotics Industry Directory**. This 348-page directory covers industrial robot models and components with an emphasis on specification information. It features 213 listings that contain specifications on accuracy, velocity, number of axes, load-carrying capacity, robot weight, floor space required, and type of control system. Also included are applications and sensors supported, price range, and number of systems installed. Side-by-side evaluations of competitive models and indexes of products and vendors complete this directory.

The **1983 Robotics Industry Directory** costs $35. Outside the U.S., it's $43. Bimonthly specification updates are $15 ($19 foreign). Contact Technical Database Corp., POB 720, Conroe, TX 77305, (409) 539-9688.

Circle 611 on inquiry card.

Yellow Pages Cover Intel Support

The **Intel Yellow Pages** lists more than 2000 products and services that support Intel architectures. The listings are organized under 10 categories, including communications, databases, technical and consulting services, and utilities. Under the main headings are a number of subheads. An alphabetical listing with brief descriptions of the more than 250 companies participating in the book and geographical and corporate/product cross-indices are provided.

The **Intel Yellow Pages** are free with a letterhead request. For full details, contact Intel Corp., Literature Department, 3065 Bowers Ave., Santa Clara, CA 95051.

Circle 612 on inquiry card.

Computer Gazette Aimed at Students

Computer Science Press has introduced the **Bits 'n Bytes Gazette**, a set of 10 mini newspapers about computers for elementary and junior high school students. Suitable for use as a classroom handout, the **Gazette** has articles and games that educate and entertain. It discusses business, medical, personal, and community uses of computers and highlights career opportunities. A guide with in-depth explanations and suggested activities is provided for instructors and parents.

The **Bits 'n Bytes Gazette**, by Rachelle Heller and C. Dianne Martin, costs $10 per set. School discounts ranging from $3 to $7.50 per set are available. Contact the Computer Science Press Inc., 11 Taft Court, Rockville, MD 20850, (301) 251-9050.

Circle 613 on inquiry card.

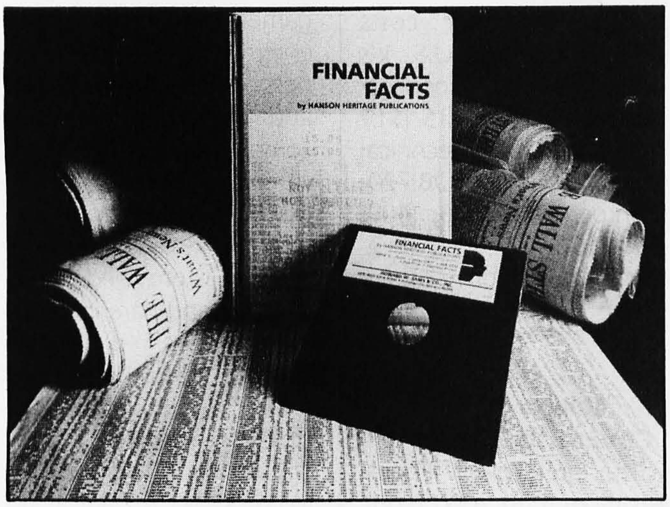
SOFTWARE

FORTH for IBM PC

Next Generation Systems has introduced a version of the FORTH programming language for the IBM Personal Computer. This package is based on the FORTH-79 Standard, and a FORTH Interest Group (fig) lookalike mode is provided. NGS FORTH uses the DOS file system, which lets you read from or write to programs and data in DOS files. Other features include an auto load screen boot, three debugging aids, and individual code, stack, and data blocks as large as 64K bytes.

NGS FORTH comes with an indexed, 200-page manual. It costs $66, plus $2 shipping. Contact Next Generation Systems, POB 2987, Santa Clara, CA 95055.

Circle 614 on inquiry card.



Financial Facts

Financial Facts performs a variety of financial functions, including depreciation, interest, loan principal, and future value. It offers four methods of calculating depreciation and amortization tables for mortgage payments and other long-term loans. It gives you the ability to compute the future value of investments, the value of an investment after a deposit or withdrawal, and nominal and effective interest rates.

Financial Facts runs on Apple II, II Plus, or IIe computers with one disk drive and 48K bytes of memory and on 64K-byte IBM Personal Computers with PC-DOS and a disk drive. It costs $59.95 and is available from Howard W. Sams & Co., 4300 West 62nd St., Indianapolis, IN 46268, (317) 298-5400.

Circle 615 on inquiry card.

Interactive Authoring System

The McGraw-Hill Interactive Authoring System helps you create computer-aided instruction courses on an IBM Personal Computer. Previous programming knowledge is not required because step-by-step onscreen directions guide you through the writing process. Your lessons can have multiple choice, matching, and fill-in-the-blank questions coupled with text, color graphics, and videotape segments. Sixteen foreground and eight background colors for graphics and text are available. The system's interactive video capabilities are compatible with many video players with remote control circuitry.

The Interactive Authoring System requires 128K bytes of memory, two 320K-byte floppy-disk drives, and color and asynchronous communications cards. For details, contact McGraw-Hill Interactive Authoring System, 26th Floor, 1221 Avenue of the Americas, New York, NY 10020, (212) 997-6458.

Circle 616 on inquiry card.

Dynacomp Enters Heath/Zenith Software Market

Dynacomp now offers 47 software packages for Heath/Zenith computer users. Applications available include engineering, statistics, education, personal finance, business, and games. For a free 64-page software catalog, write to Dynacomp Inc., Department C4, 1427 Monroe Ave., Rochester, NY 14618, or call (716) 442-8960.

Circle 617 on inquiry card.

Compaq Number Cruncher

Pyramid Data Ltd. has released the Number Cruncher, a financial-modeling system for the Compaq portable computer. This program blends text editing and calculating capabilities into a flexible modeling program. Fixed rows and columns are not used by the Number Cruncher, which permits user-defined report formats. Standard row and column mathematics functions are provided, as are commands that let you add, subtract, multiply, and divide blocks of rows and columns to produce a single total.

The Number Cruncher, which requires 128K bytes of memory, costs $395. Complete details are available from Pyramid Data Ltd., POB 10116, Santa Ana, CA 92711, (800) 521-2233; in California, (714) 639-1527.

Circle 618 on inquiry card.

Accountant for TI Professional Computer

Continental Software has reconfigured The Home Accountant for the 128K-byte Texas Instruments Professional Computer. This menu-driven program can maintain 200 budget categories, track five checking accounts, reconcile bank statements, record transactions, and handle 2000 transactions per month. It offers a forecasting module, graphic capabilities, and one-key English-language commands. The Home Accountant's printout function, which can be used for writing checks or organizing data for readouts, works with most dot-matrix and daisy-wheel printers.

The Home Accountant runs on MS-DOS using MS-BASIC. The suggested price is $150. Contact Continental Software, 11223 South Hindry Ave., Los Angeles, CA 90045, (213) 417-8031.

Circle 619 on inquiry card.

Moon Hopper Features Graphics, Sound, and Colors

Moon Hopper from Computerware is an arcade-type game for the Radio Shack TRS-80 Color Computer and the TDP-100. While on test maneuvers of the new Moon Hopper space exploration vehicle, you are attacked by a swarm of aliens. To reach the next moon base, you must hop and roll over craters and rocks while

blasting the attackers with your phasers. Graphics andsound complete this adventure.

Moon Hopper requires 32K bytes of memory. It's available on floppy disk or cassette for $29.95 and $24.95, respectively. Order it directly from Computerware, Suite 102, 4403 Manchester Ave., POB 668, Encinitas, CA 92024, (619) 436-3512.

Circle 620 on inquiry card.

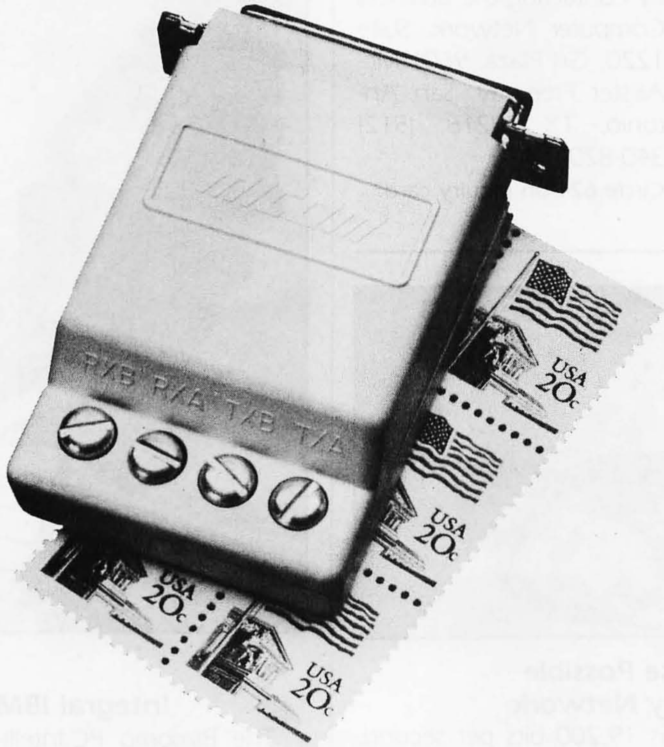
Accounting Control for Rainbow

The Business Accounting Control Systems (BACS) for Digital Equipment Corporation's Rainbow 100 is marketed by American Business Systems. BACS modules for the Rainbow are single-user programs running under CP/M-86. BACS provides you with interactive menus, extensive error checking, full operator prompting, and the ability to display reports on screen. The five-module series comprises order entry/inventory control, accounts receivable, accounts payable, payroll, and general ledger programs. BACS is written in RM COBOL.

Minimum hardware requirements are 64K bytes of memory, a 24-line by 80-character screen, and a 132-column printer. Further information is available from American Business Systems Inc., 3 Littleton Rd., Westford, MA 01886, (617) 692-2600.

Circle 621 on inquiry card.

COMMUNICATIONS



Compact Datasets

Micom's Micro400 Local Dataset Models 430 and 431 connect terminals and computers in a local environment. Intended for use on a college campus or within a building, these devices provide full-duplex asynchronous communications for up to 3 miles at 9600 bps (bits per second). The Model 430 can cover more than 1 mile at 19,200 bps. They plug directly into an RS-232C interface and are powered by the host system. Both models are about the size of a package of cigarettes.

The Model 430 Line Driver is designed for use on customer lines. It costs $85. The Model 431 Local Dataset is intended for operation on telephone company-supplied limited-distance private circuits. It's available for $95. For further details, contact Micom Systems Inc., 20151 Nordhoff St., Chatsworth, CA 91311, (213) 998-8844.

Circle 622 on inquiry card.

Software, Hard-Disk Create Network

Link-Bos is an integrated hardware and software approach to networking. It provides the ability to link multiple users, computers, operating systems, and selected applications programs through a hard-disk unit. Link-Bos software allows sharing of data with a mix or a match of such 8-, 16-, or 32-bit computers as Radio Shack, Victor, and Zenith. When running any one of the more than 50 Bos applications programs, all computers in the network can simultaneously use the same data. Each single-user operating system and software will work unchanged.

Link-Bos parallels the operating system supplied with your system. All computers in the network are connected to a common Winchester hard-disk unit that serves as the network storage area. Data and messages move between workstations through the Winchester unit.

Bos application programs are available in accounting, farming, timekeeping and other areas. Complete details can be obtained from Aid Data Systems Inc., Route 3 Center, POB 750, Millersville, MD 21108, (301) 621-9494.

Circle 623 on inquiry card.

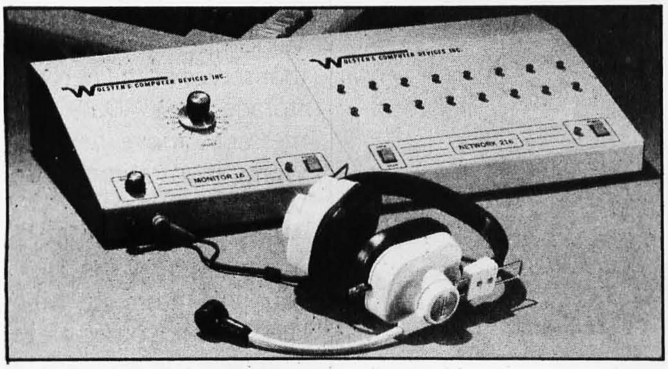
Telecommunications Distribution Network

Business Computer Network (BCN) is a telecommunications distribution system that provides access to existing databases and online services such as The Source, Dow Jones, and Western Union's EasyLink. Databases are accessed from a menu, and BCN automatically signs on the user. Point-to-point communications software that lets different brands of computers work together is one feature of this system. Software downloading, which lets users purchase software at reduced rates

directly from the BCN computer center, is also available. Additional network services include electronic mail, an information system, and an electronic magazine and newsletter.

Currently, BCN does not charge subscriber fees. A minimum monthly charge of $5 covers operating expenses and services. A free system disk and a system overview can be obtained by contacting the Business Computer Network, Suite 1220, Gill Plaza, 9601 McAllister Freeway, San Antonio, TX 78216, (512) 340-8201.

Circle 624 on inquiry card.



Classroom Use Possible with Two-Way Network

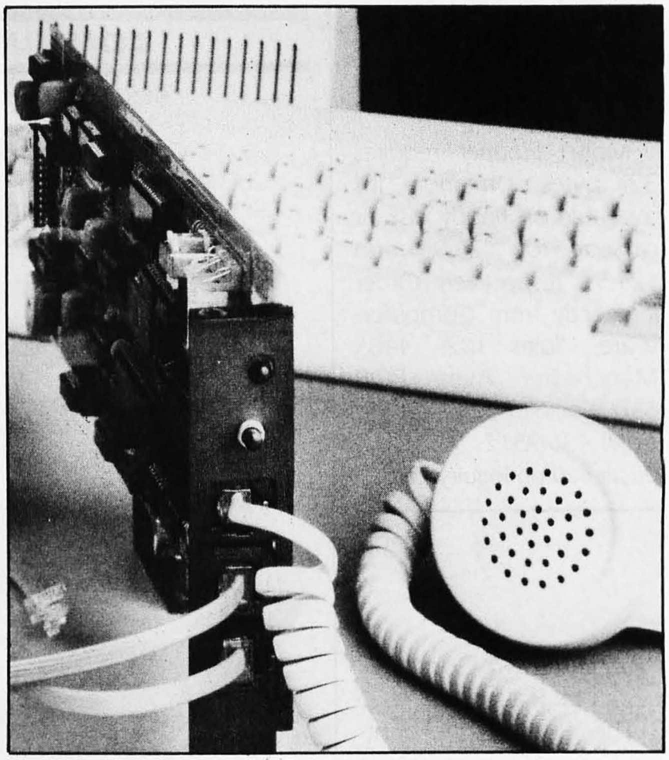
The Network 216 and the Monitor 16 are at the heart of the first network system designed for complete two-way communications between a master station and its satellites. This system, created by Wolsten's Computer Devices, is designed for any situation in which more than one computer is used at a given time, such as in a computer class. Uploading, downloading, and the ability to send information to a printer are provided. Communication is both video and audio. A dedicated computer is not required.

The Network 216 scans up to 16 active Atari computers and requests if any action, say uploading or sending data to a printer, is required. It automatically proceeds from one computer to another, skipping inactive units. Its data rate is 19,200 bits per second. The Network 216 uses Atari DOS and can handle up to four disk drives and a printer.

The Monitor 16 expands and enhances the system. It can monitor any of the 16 Ataris individually at the turn of the dial. When used with any television set, the Monitor 16 can display the same video information that is appearing on each computer. Audio communication is made possible through the use of a headset with an attached microphone.

A hard-disk option will be available for the system. For additional information, contact Wolsten's Computer Devices Inc., 99 Washington St., East Orange, NJ 07017, (201) 678-0408.

Circle 625 on inquiry card.



Integral IBM PC, XT Modem

The Bizcomp PC:Intellimodem is an integral Bell 212-compatible modem for the IBM Personal Computer. It can communicate at 300 or 1200 bps (bits per second) and offers integrated voice and data capabilities. Its telephone handset permits program-controlled switching between voice and data communications without requiring a redial. The handset, for example, can be used to monitor communications or to supply voice and Touch-Tone input under control of the Personal Computer. Standard features include autodial, auto-repeat dial, and auto-answer. The PC:Intellimodem comes with a menu-driven communications software package that provides more than 50 commands and status checks.

The PC:Intellimodem is marketed through a network of IBM dealers. Its suggested list price is $499. Contact your local IBM dealer or write to Inquiries Manager, Bizcomp Corp., POB 7498, Menlo Park, CA 94025.

Circle 626 on inquiry card.

IEEE-488-to-Ethernet Interface

An interface board that connects computers with an IEEE-488 GPIB port to an Ethernet local-area network has been announced by Xebec. VLSI technology is used in this board to carry out the physical and data-link control layers of the ISO Ethernet specification. A dedicated microprocessor provides high-level command protocols to the

host system software. Unwanted receive packets are automatically discarded. Standard features include a 2K-byte transmit buffer, two 2K-byte receive buffers, automatic retransmission after collision, and an onboard encoder/decoder and transceiver. Software-configurable partial multicast address filtering is provided, and the board offers four software-specified address reception modes. Other software features include a statistics mode and self-test and diagnostics. Full details are available from Xebec, 432 Lakeside Dr., Sunnyvale, CA 94086, (408) 733-4200.

Circle 627 on inquiry card.

Personal Systems Technology Inc., Suite A, 15801 Rockfield Blvd., Irvine, CA 92714, (714) 859-8871.

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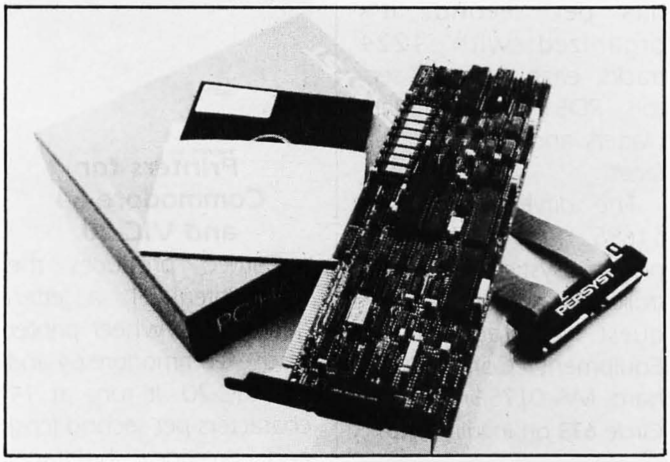


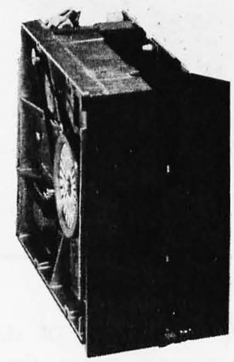
PC to HASP/RJE Communications System

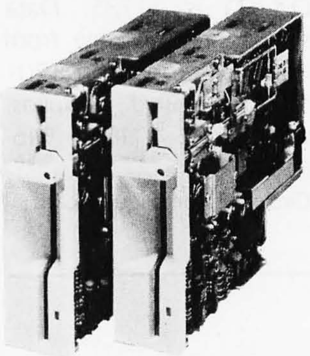
Persyst's DCP/88 Distributed Communications Processor is an intergrated hardware and software system that permits IBM Personal Computer and PC XT users to perform HASP/RJE (Houston Automatic Spooling Program/remote job-entry) functions with IBM mainframes. Incorporating an 8088 microprocessor, the DCP/88 controls all communications, sending and receiving data simultaneously with program execution on the PC. It supports 64K bytes of dual-processor RAM and can accommodate asynchronous, bisynchronous, HDLC, and SDLC line protocols. The DCP/88 requires a single card slot and can function as a parallel processor for program or subroutine execution.

PC/HASP software supports up to seven multileaved input and seven output job streams concurrently. As many as six reader streams and six print/punch streams can be initiated from the PC console. Centronics- and Dataproducts-compatible printers up to 600 lines per minute are supported, and print data can be spooled to disk for off-line printing.

Minimum system requirements are PC-DOS, 64K bytes of memory, a monochrome display, and a disk drive. The suggested price is $1690; quantity discounts are offered. Contact

MASS STORAGE





Amdisk-V Drives Plug-compatible with Industry Standard

Amdek Corporation's half-height double-density double-sided Amdisk-V floppy-disk drives are plug-compatible with industry-standard 5¼-inch drives. Designed for original equipment manufacturer applications, the drives offer industry-compatible data-transfer rates, recording formats, and disk rotation speeds. They are said to offer a high random-access speed as a result of a head mechanism built with a steel-belt access device and ceramic magnetic heads.

Full specifications and pricing information are available from Amdek Corp., 2201 Lively Blvd., Elk Grove Village, IL 60007, (312) 364-1180.

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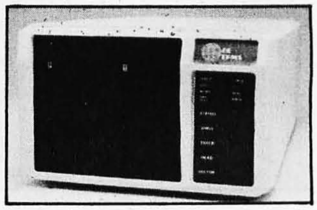

Recording Technique Boosts Storage

Sunol Systems' Corvus-compatible mass-storage system uses a Run-Length Limited Coding technique that is said to provide up to 50% more storage than common Winchester disk units. For example, a 12-megabyte Winchester disk after formatting has 10 megabytes of usable storage. Using the same 12-megabyte design and the coding technique, the Sunol unit is claimed to provide 14 megabytes of storage.

Sunol drives have a data transfer rate of 7500 bits per second and feature a status display with current track, head, and sector locations. More than 23 different host adapters for such microcomputers as Apple and Victor are available.

Options include multiplexer and the Omninet local-area network. Contact Sunol Systems, 1072 Serpentine Lane, Pleasanton, CA 94566, (415) 484-3322.

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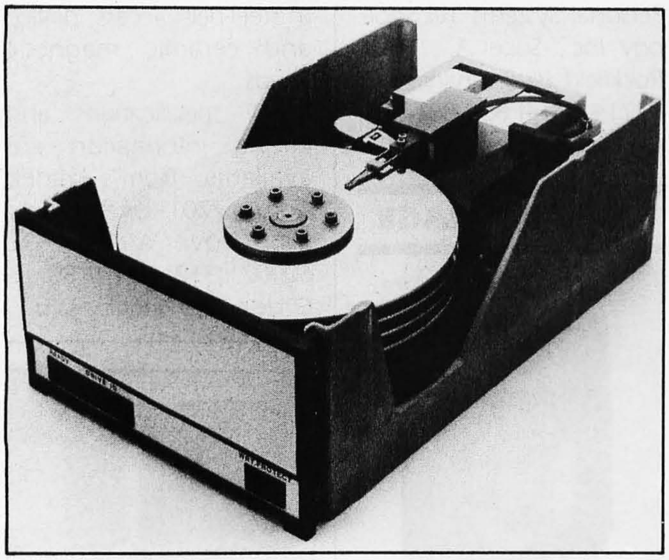

Large-Capacity 8-inch Fixed Disk

An 8-inch Winchester fixed-disk drive, the D-1100 from Disctron can store 111.5 megabytes of formatted data. System hardware includes mini Winchester heads, plated media, linear voice coil, and closed-loop servo positioning. Data is carried on four thin-film fixed disks, with each surface storing 15.9 megabytes of data. The average access time is 35 milliseconds. In manufacturer quantities, the D-1100 is $1735. Data sheets are available from from Disctron Inc., 1701 McCarthy Blvd., Milpitas, CA 95035, (408) 946-6692.

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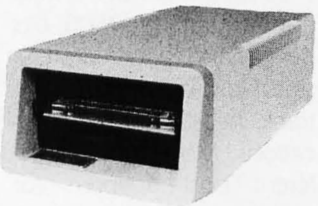

Cartridge Tape System for IBM PC

A cartridge tape subsystem for the IBM Personal Computer is available from Alloy Computer Products. The compact PC-Backup cartridge drive is a 4-track, 6400-bpi unit that can handle 13.4-megabytes of data per 450 feet of tape or 16.5 megabytes of data on the 555 cartridge. It can serve as a medium for data storage or retrieval or as an onsite Winchester backup. PC-Backup comes with TIP (tape interchange program) software for controlling read, write, and dump operations. Utilities for customizing drive operations are provided.

PC-Backup costs $1995. For full details, contact Alloy Computer Products, 12 Mercer Rd., Natick, MA 01760, (617) 655-3900.

Circle 632 on inquiry card.

Winchester Technology for DEC Professional 350

Digital's RD51, a 10-megabyte 5¼-inch Winchester disk, interfaces with the Professional 350. Its average access time is 85 ms (milliseconds); average rotational latency is 8.33 ms. RD51 characteristics include 345 tracks per inch with a density of 9074 bits per inch and a peak data-transfer rate of 5000 bits per second. It's organized with 1224 tracks, each with 16 sectors. RD51 has two data platters and four data surfaces.

The drive alone costs $1695. Pricing for complete subsystems with controllers is available by request. Contact Digital Equipment Corp., Maynard, MA 01754.

Circle 633 on inquiry card.

Portable Minicassette Program Loader

The MTL-II is a portable, minicassette program loader from Braemar Computer Devices. Intended as an I/O device for RS-232C applications, the MTL-II can store and retrieve approximately 244K bytes of data on a single cassette. This unit reads and writes ANSI-compatible tape for loading programs or remotely collected data through a standard RS-232C port. Light-emitting diodes provide status line and error indication. Other features include a membrane keyboard for control commands, an integral tape deck that uses 50- or 80-foot tapes, and selectable data rates ranging from 150 to 9600 bits per second.

In quantity, the MTL-II costs $350. Further details are available from Braemar Computer Devices Inc., 11950 12th Ave. S, Burnsville, MN 55337, (612) 890-5135.

Circle 634 on inquiry card.

PRINTERS

Printers for Commodore 64 and VIC-20

Cardco produces the Cardprinter/LQ1, a letter-quality daisywheel printer for the Commodore 64 and the VIC-20. It runs at 14 characters per second (cps) and provides boldface, shadow, and underline printing in normal or proportional spacing modes of 10, 12, or 15 characters per inch. Options include tractor and cut-sheet feeders and a keyboard for direct printing. The suggested retail price is $599.95.

The Cardprinter/DM1 is also available from Cardco. This dot-matrix impact printer can print 40 columns of text on 3-inch-wide adding-machine roll paper. Full Commodore graphics, 50-cps operation, and high-resolution dot-addressable graphics are featured. It costs $149.95. For complete specifications, contact Cardco Inc., 313 Mathewson Ave., Wichita, KS 67214, (316) 267-6525.

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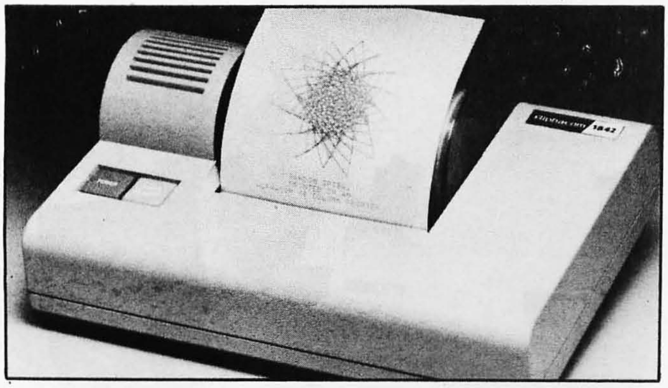

Morrow Introduces Letter-Quality Printers

Three letter-quality, daisywheel printers have been introduced by Morrow. The MP100, MP200, and MP300 offer Shannon text print speeds of 14, 20, or 31 characters per second, respectively. They operate with all Morrow computer systems, including the Micro Decision and the Decision I. Bidirectional printing and noise levels below 65 decibels are standard. Word-processing functions such as boldface, underlining, centering, subscript, and superscript are supported. Standard multistrike Silver-Reed ribbons are used. The MP200 and MP300, both 132-column printers, can automatically load single-sheet paper. The prices range from $595 to $1195. Complete details are available from Morrow, 600 McCormick St., San Leandro, CA 94577, (415) 430-1970.

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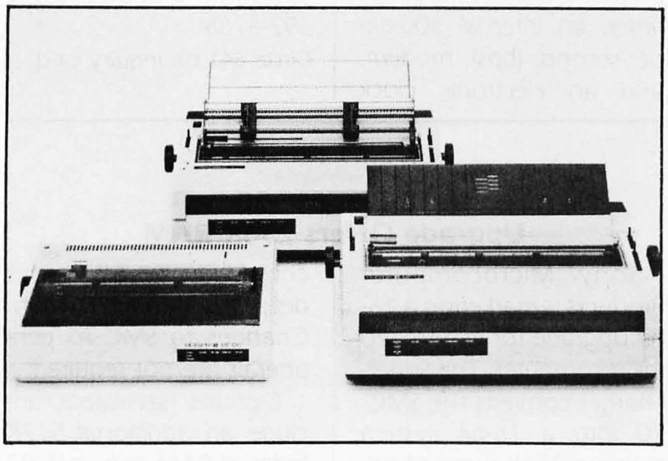


Printer with a Personality

Alphacom is marketing a 40-column thermal printer targeted at the OEM market. The Alphacom 1842 provides applications flexibility through personality (i.e., interface) modules that manage communications with the host computer, generate characters, and determine the character set and matrix. A 4-pound unit featuring a single-chip microprocessor controller and an Olivetti print mechanism, the 1842 is housed in an impact-resistant case, measuring 10½ by 7½ by 4 inches. It runs at 2 lines per second in either a graphics or character mode.

With an interface module, the single-unit price is $199.50. Interface modules are available for Centronics, IEEE-488, and RS-232C ports. Teletext and videotex versions are in production. For information, contact Alphacom, 2323 South Bascom Ave., Campbell, CA 95008, (408) 559-8000.

Circle 637 on inquiry card.

Low-Cost Letter-Quality Printer

The Transtar Model 130 is advertised as the first daisy-wheel printer to provide letter-quality print and full word-processing functions for less than $900. Produced with users of IBM PC, Apple, and Osborne computers in mind, the Model 130 is compatible with all word-processing software that uses Diablo routines. An auto-load feature lets you load cut-sheet paper to one of four switch-selectable positions designed for most common printing functions. Fully formed characters are printed, bidirectionally, at 18 cps (characters per second) Shannon text rating; the maximum speed is 20 cps. Cartridge ribbons are available in cloth or single- or multistrike Mylar film, and 96-character plastic print wheels come in pica, elite, or proportional styles. Proportional spacing is supported if your word processor is so equipped.

Two versions of the printer are offered. The Model 130P is an 8-bit Centronics-compatible parallel interface. It costs $895. The Model 130S works with RS-232C serial interfaces. It has a standard 2K-byte print buffer and switch-selectable transmission rates ranging from 300 to 2400 bits per second. The Model 130S supports the DTR busy protocol, with XON/XOFF and ETX/ACK protocols under DIP switch control. The suggested retail price is $950. A bidirectional tractor-feed option lists for $149. For more details, contact Transtar, 2110 116th NE, POB C-96975, Bellevue, WA 98009, (206) 454-9250.

Circle 638 on inquiry card.

PERIPHERALS

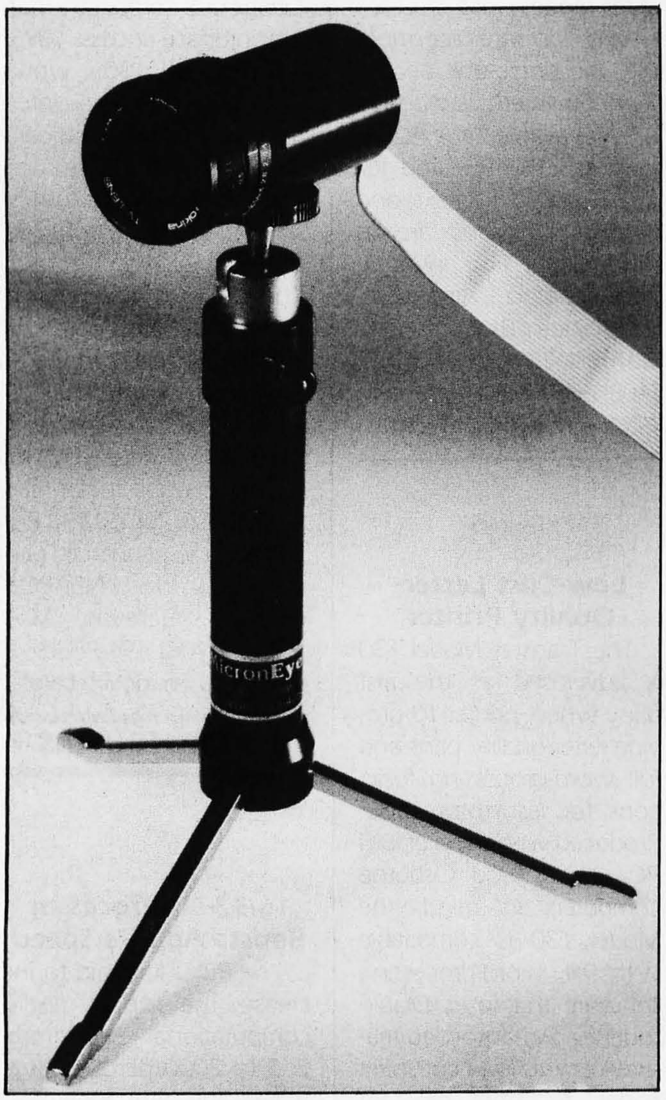
16/32-Bit Processor Boosts Apple's Speed

The PDQ II is said to increase the Apple II/IIe's computational speed from 200 to 2000 percent. Produced by Enhancement Technology Corporation, the PDQ II incorporates a 16/32-bit MC68000 microprocessor and 256K bytes of RAM and provides such productivity capabilities as multiple printer/communications buffering, pseudodisk functions, and track buffering. Most standard Applesoft BASIC programs are supported, as are advanced 16/32-bit software,

Apple DOS 3.3, and the UCSD p-System interpreter.

RAM memory expansion to 1 megabyte and Unix-like operating systems are in the works. PDQ II costs $1595. Contact Enhancement Technology Corp., POB 1267, Pittsfield, MA 01202, (413) 445-4219.

Circle 639 on inquiry card.



Microcomputer Vision System

The Microneye vision system transmits images to your computer for mass storage of graphics displays and image analyses. Possible applications include robotics, security, and text recognition. It's capable of 256 by 128 resolution and operating speeds of up to 15 frames per second.

Microneye is currently available for the Apple II Plus and IIe, IBM Personal Computer, Commodore 64, and the Radio Shack TRS-80 Color Computer. It lists for $295. For complete specifications, contact Micron Technology Inc., 2805 East Columbia Rd., Boise, ID 83706, (208) 383-4050.

Circle 640 on inquiry card.

Telephone/Terminal Runs Two Lines

The Displayphone is a two-line business telephone combined with a 7-inch terminal screen produced by Northern Telecom and distributed by May-Craft Information Systems. This device is designed for accessing databases such as The Source and Dow Jones, even while you're on another line. Displayphone provides an internal speaker/phone, a call directory, call timer, an internal 300-bit-per-second (bps) modem, and an electronic clock with time and date. The screen format is 24 lines by 80 columns. Displayphone supports a separate printer and comes with an external RS-232C data connector offering speeds of up to 1200 bps.

Further information on the Displayphone is available from May-Craft Information Systems Inc., 4312 Beltwood Parkway S, Dallas, TX 75234, (800) 527-7456; in Texas, (214) 392-3766.

Circle 641 on inquiry card.

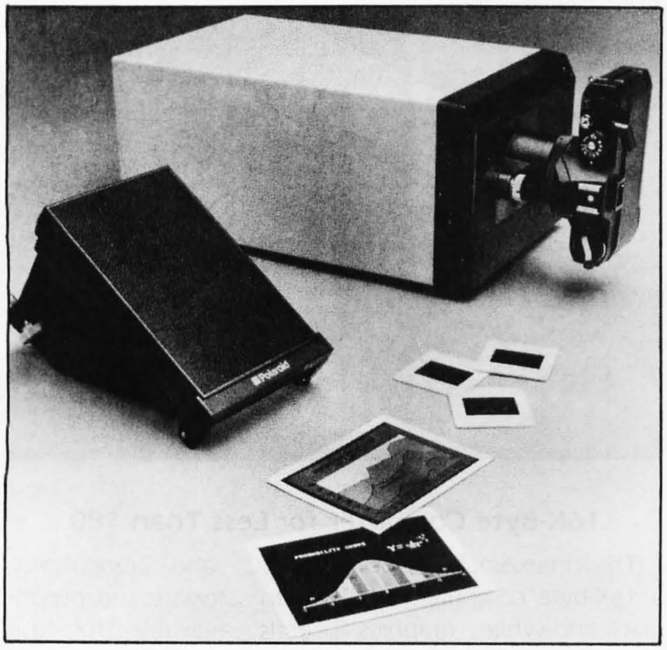
16-Bit SMC-70 Upgrade Offers 256K RAM

Sony Microcomputer Products is marketing a 16-bit upgrade for its SMC-70 microcomputer. The Supercharger converts the SMC-70 into a 16-bit system carrying 256K bytes of onboard RAM (random-access read/write memory). Based on Intel's 8086 microprocessor operating at 5 MHz, the Supercharger is capable of supporting CP/M and MS-DOS concurrently. It measures 14⅜ inches wide by 6¼ inches deep by 4⅝ inches high. Changes to SMC-70 peripherals are not required.

Options available include an additional 512K bytes of RAM and an 8087 floating-point mathematics processor. The Supercharger costs less than $1000. Sony Microcomputer Products, Sony Dr., Park Ridge, NJ 07656.

Circle 642 on inquiry card.

What's New?



Computer Image Recorder Snaps Instant Photos

The Polaroid Palette, an interactive film recorder, produces high-quality 35-mm slides and instant photographs of computer graphics images in either black-and-white or color. Featuring a flat-faced, medium-resolution monochrome video screen with a tricolor filter wheel, the Palette allows even monochrome displays with graphics capabilities to produce color prints for presentations, displays, record keeping, or working copies. It connects to the computer through black-and-white video and RS-232C lines. It's supplied with interactive software for matching exposure parameters to the film and allowing the user to control color selection and location. The software also lets you transfer images from the display to the film without modification.

Palette can be used with Apple II Plus, Apple IIe, and IBM Personal Computers. Several graphics packages are supported. The suggested retail price is $1300, including software, a 35-mm camera back and an adapter plate, and transparency system hardware. Further details are available from Polaroid, 575 Technology Square, Cambridge, MA 02139, (617) 577-2000.

Circle 644 on inquiry card.

Eight-Color, High-Resolution RGB Monitor

The Model SC-300 color-display monitor is compatible with Apple II/III, IBM PC, NEC, and other popular computers. A 13-inch red/green/blue high-resolution monitor, the SC-300 offers a display format of 80 characters by 25 lines in a 5- by 7-dot grid. Key specifications include eight colors plus intensity (total 16 colors), a digital amplifier video circuit, and a center resolution of 700 dots (minimum).

The SC-300 monitor costs $899. Complete technical specifications are available from Sakata U.S.A. Corp., 651 Bonnie Lane, Elk Grove Village, IL 60007, (800) 323-6647; in Illinois, (312) 593-3211.

Circle 645 on inquiry card.

SYSTEMS

Concurrent Processing

The Xerox 16/8 Professional Computer combines 16- and 8-bit microprocessors for concurrent processing of two tasks. The 16-bit operating systems are CP/M-86 and MS-DOS; CP/M-80 handles the 8-bit work. The 16-bit Intel 8086 processor provides 128K bytes (expandable to 256K bytes) of user memory, while the 8-bit Zilog Z80A has 64K bytes. Standard features include a 12-inch black-and-white display with a 24 by 80 format, two serial and two parallel ports, and a low-profile keyboard with 12 user-definable keys, 6 system function keys, a 10-key numeric keypad, cursor keys, and a Help key. Video attributes such as blinking characters, high and low intensity, inverse video, and graphics are provided. Storage options, which can be tailored to specific needs, include two single-or double-sided 5¼- or 8-inch floppy-disk drives and a 10-megabyte fixed-disk drive that comes with a double-sided 8-inch disk drive.

Two letter-quality Diablo printers, 5- or 10-slot expansion modules, Ethernet network communications, and a variety of applications software are available as options. Prices begin at $3395; quantity discounts are offered. Contact Xerox, Office Products Division, 1341 West Mockingbird Lane, Dallas, TX 75247.

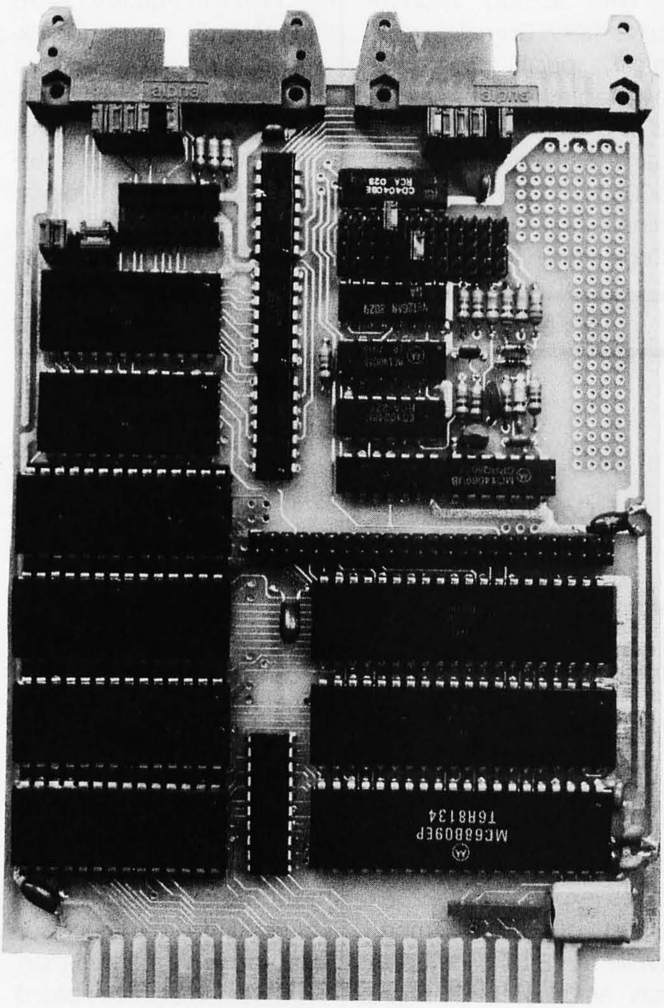
Circle 646 on inquiry card.

Automated Language System

ALPS, Automated Language Processing Systems, is a multilingual translator and authoring workstation capable of serving as a master station in a network or as a stand-alone unit. The basic ALPS word processor lets you work in more than 100 Roman-alphabet-based languages and offers continually accessible dictionary-building and lookup capabilities. This system features multiple-window 80- and 130-column display screens, a letter-quality multilingual printer, and multilingual keyboards. Floppy-disk and hard-disk storage capacities range from 10 to 300 megabytes. Network and telecommunications capabilities permit access to term banks and terminology-exchange networks.

A full range of optional integrated writing aids, multiple unit configurations, and financial software are available. For complete details, contact ALPS, 190 West 800 North, Provo, UT 84601, (801) 375-0090.

Circle 647 on inquiry card.

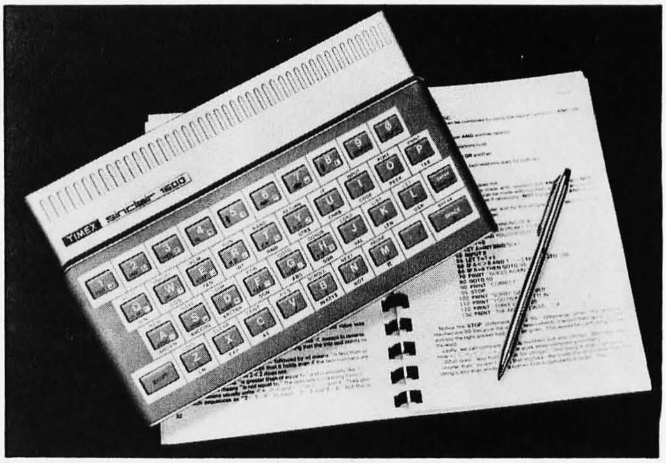


Single-Board 6809 Computer

The 6809 Control Module from Wintek Corporation is designed for such applications as dedicated control, protocol conversion, and robotics. This system comes with a watchdog timer, real-time clock, two RS-232C ports, four parallel ports with handshaking, and up to 64K bytes of RAM and EPROM. It's built on an industry-standard 4½- by 6½-inch card, and it's compatible with all Wintek I/O modules.

Options include additional ROM or CMOS RAM memory modules and 6809 development software. Prices begin at $245; quantity discounts are available. A manual alone costs $5. For full details, contact Wintek Corp., 1801 South St., Lafayette, IN 47904, (317) 742-8428.

Circle 649 on inquiry card.



16K-Byte Computer for Less Than $80

The Timex/Sinclair 1500, a 16K-byte computer, has black-and-white graphics capabilities, a 40-key typewriter-like keyboard, and the ability to use either standard audio cassettes or mini-cartridge software. Other features include 22 graphics and 22 special-character keys, Extended BASIC, and compatibility with software and peripherals available for the TS1000. RAM memory is expandable to 32K bytes.

The suggested retail price is $79.95. Contact Timex Computer Corp., Middlebury, CT 06762.

Circle 650 on inquiry card.

System Expands for Multiple Users

Cromemco's CS-3A series of general-purpose microcomputers offers multiuser, multitasking capabilities. The basic CS-3A comes with a Z80A, 64K bytes of memory, two slimline 8-inch Tandon disk drives with a total of 2.4 megabytes of storage, and CROMIX and CDOS operating systems.

System expandability begins with a 21-slot backplane and a line of bus-compatible board products. A dual-processor option couples the Z80A with the 68000 microprocessor. Other hardware available includes up to 4 megabytes of user memory and 21 megabytes of fixed-disk Winchester storage. Software options such as error checking and correcting memory and a multiuser, multitasking operating system are offered. C, LISP, FORTRAN, COBOL, Pascal, BASIC RPG-II, and RATFOR are supported. When equipped with dual processors, the CS-3A can run FORTRAN-77 and Level II COBOL.

The basic CS-3A system costs $6995. The dual-processor version with 256K bytes of memory is $7995. Full specifications are available from Cromemco Inc., 280 Bernardo Ave., POB 7400, Mountain View, CA 94039, (415) 964-7400.

Circle 651 on inquiry card.

Color Computer for Beginners

The Radio Shack TRS-80 Micro Color Computer Model MC-10 is targeted at first-time computer users. A 4K-byte machine that's software-compatible with Color BASIC, the MC-10 offers low-resolution graphics, keyword input using two keystrokes, and text and graphics displays in a 32-character by 16-line format. For expansion, serial and cassette ports are provided. The MC-10 connects to standard color or black-and-white televisions through its built-in RF modulator.

A plug-in 16K-byte memory-expansion module will soon be available. With a manual and monitor-connection cables, the MC-10 costs $119.95. For more information, contact your local Radio Shack Computer Center or Radio Shack, 1800 One Tandy Center, Fort Worth, TX 76102.

Circle 652 on inquiry card.

Software Library Comes Standard

The Multiplan electronic spreadsheet, the Wordstar 3.3 word processor, Mailmerge 3.3, CBASIC, CP/M Plus, a VT-100 terminal emulation package, and Digital Research's GSS-Graph graphics package and the GSX-80 graphics-device driver comprise the software library supplied with the Visual 1050 Personal Computer. System hardware is made up of two 400K-byte floppy-disk drives, 96K bytes of RAM, a high-resolution (640 by 300), bit-mapped monochrome display, a detached 93-key keyboard, and printer, modem, and Winchester disk-expansion ports.

A plug-in, dual-port serial card, 64K bytes of memory, and a 5-megabyte hard-disk are available as options. The Visual 1050 lists for $2695. For more information, contact Visual Technology Inc., 540 Main St., Tewksbury, MA 01876, (617) 851-5000.

Circle 653 on inquiry card.

IBM PC Look-Alike

The Sanyo MBC 550 is a 16-bi IBM Personal Computer look-alike. Standard features include an 8088 microprocessor, 128K bytes of memory, a 160K-byte floppy-disk drive, color graphics capabilities, and a Centronics-type printer port. Supplied software includes Sanyo BASIC, utilities, a word processor, and diagnostics. MS-DOS, an 8087 mathematics processor, 320K to 640K bytes of disk storage, monochrome or color monitors, and an extra 128K bytes of memory are some of the options available.

Prices for the MBC 550 begin at $995. Contact Sanyo Business Systems Corp., 51 Joseph St., Moonachie, NJ 07074, (201) 440-9300.

Circle 654 on inquiry card.

16-Bit Computer Suited for Home and Business

A 16-bit desktop computer, the Toshiba T300 is designed for personal and business use. This machine has an 8088 processor, 192K bytes of memory, a 103-key detached keyboard, three video interfaces, a serial RS-232C port, and a Centronics-compatible parallel port. Three display monitors are offered: a 12-inch green screen, an 8-color 14-inch version, and a 14-inch display with 16 colors available from a palette of 256. Each tilt-and-swivel monitor has a dot-addressable resolution of 640 by 500. Mass storage is provided by one or two *slimline* 5¼-inch double-density, double-sided floppy-disk drives, each with a capacity of 640K bytes. MS-DOS and T-BASIC16 are standard, and CP/M-86 and CBASIC-86 are available as options. RAM memory is expandable to 512K bytes. For full details, contact Toshiba America Inc., Information Systems Division, 2441 Michelle Dr., Tustin, CA 92680, (714) 730-5000.

Circle 655 on inquiry card.

FOREIGN

Adjustable Computer Tables

Emmein B. V. is exporting computer terminal and keyboard tables with electronically controlled height adjustments. Each high-grade steel table has two independently adjustable leaves that permit the keyboard and terminal to be raised or lowered. Lifting systems are concealed behind a panel, and each table comes with a cable duct for the terminal's cables and power supply.

Three models, each with a different adjustment method, are offered: the electronic model permits recording of the desired height for automatic adjustments; the push-button model uses electric motors and screw drives; and the mechanical model adjusts each leaf using balanced weights.

Sides leaves are available for each table. For informa-

What's New?

tion, write to the Consulate General of the Netherlands, Economic Section 6a2/82, One Rockefeller Plaza, New York, NY 10020.

Circle 656 on inquiry card.

Vision Systems

Digithurst Ltd. sells two vision systems for microcomputer applications ranging from education to artificial intelligence. The Microsight 1 is a CCTV-based unit that uses a Micro Eye camera interface to send 8-bit digitized video images to a computer. The Microsight 2, based on a solid-state camera, employs a 128 by 128 CID sensor to capture an image and a high-speed interface to pass the image back to the computer either as 8-bit digital video or as threshold video.

Both systems use a command processor and disk I/O and camera-control routines. Other software permits interactive adjustments of camera settings and display of facsimile and binary images. A boundary/edge detection program is included. The Microsight 1 costs £499. The Microsight 2 is £199. Contact Digithurst Ltd., Leaden Hill, Orwell, Royston, Hertsfordshire SG8 5QH, England; tel: (0223) 208926.

Circle 657 on inquiry card.

P-system for IBM PC

Network Consulting has configured a version of the UCSD Pascal p-System for the IBM Personal Computer. Purported to run one to five times faster than its competition, this system features a rewritten 8088 interpreter and floating-point programs that manipulate real numbers. Its long-integer support is said to be three to five times faster than previous systems.

Dealer prices begin at $845. Benchmarks and marketing information are available from Network Consulting Inc., Suite 110, Discovery Park (Willingdon Site), 3700 Gilmore Way, Burnaby, British Columbia V5G 4M1, Canada, (604) 430-3466.

Circle 658 on inquiry card.

Joystick Port for VIC

MFJ Electro Enterprises offers Commodore VIC-20 users an add-on port for a second joystick for programming and running two-player games. Programming instructions and a sample two-player game on cassette are provided in this $21.50 package. Contact MFJ Electro Enterprises, POB 13076, Kanata, Ontario, K2K 1X3 Canada, (613) 592-2962.

Circle 659 on inquiry card.

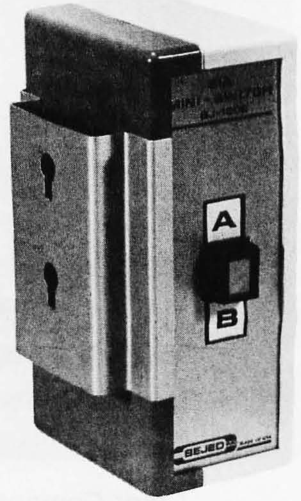
Graphics Display Terminal

Nippon Computer Company's NJC-M1212 graphics display terminal is suitable for business graphics and graphics information retrieval. Standard features include a 12-inch green screen, 640- by 486-dot resolution, 1-microsecond per dot high-speed drawing, three communications ports, and a Tektronix 4010/4014 emulator. The complete package is provided with a graphics processor, communications software, and a keyboard.

The list price is $2600. Contact Nippon Computer Co. Ltd., Naito Building, Nihonbashi Hamacho 2-25-1, Chuo-ku, Tokyo 103, Japan; tel: 03-669-3066; Telex: 0-2523475.

Circle 660 on inquiry card.

MISCELLANEOUS



RS-232C Switch and Indicating Adapter

Bejed's Model BJ-1208 EIA Mini-Switch provides manual switching between many RS-232C devices, such as a modem or computer. Common leads 2, 3, 4, 5, 6, 8, and 20 are switched, while 1, 7, and 10 are hard-wired through. Its nonlocking push button changes color when operated. In single units, the BJ-1208 costs $98, including mounting hardware.

Also available from Bejed is the Model BJ-1218 Indicating Adapter. Its LEDs provide the status information on RS-232C data leads 2, 3, 4, 5, 6, 8, and 20. All other leads are carried through without indication. The Model BJ-1218 is offered in two versions for different connector arrangements. Either model costs $35.

Quantity discounts on these devices are offered. For more information, contact Bejed Inc., 4824 Northeast 42nd, Portland, OR 97218, (503) 281-8153.

Circle 661 on inquiry card.

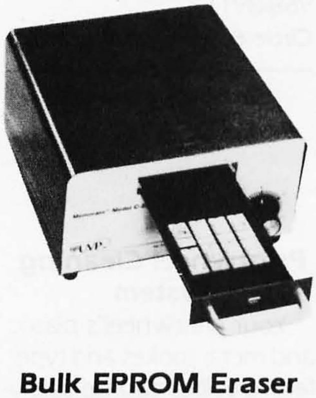
What's New?

Colored-Coded Disks Aid Filing

Colored disks from Cenna Technology help you file, code, and identify your programs. Five different colors are supplied with each 10-pack: red, orange, yellow, green, and blue. Other color combinations are available on request. The disk cartridge material is high-quality Homopolymer PVC. Single-sided, double-sided, and quad-density 5¼- and 8-inch disks are offered.

The suggested end-user price for a 10-pack of single-sided 5¼-inch disks is $34.95. Dealer pricing is available. Contact Cenna Technology Inc., 183 Cottage Ave., Sandy, UT 84070, (801) 261-1600.

Circle 662 on inquiry card.



Bulk EPROM Eraser Works in Minutes

The Memorase C-25 erases up to 25 EPROMs in 10 minutes. It comes with a filtered viewport, high-intensity grid lamp, 60-minute timer for simplified exposure settings, and a safety interlock. In single units, the C-25 costs $395. A desktop version capable of erasing 1 to 8 EPROMs, the Model DE-4 costs approximately $78. Volume discounts are available. Contact UVP Inc., 5100 Walnut Grove Ave., POB 1501, San Gabriel, CA 91778, (213) 285-3123.

Circle 663 on inquiry card.

Terminals Upgraded to CP/M Systems

The Microfit Instant Computer upgrades your Televideo or Lear Siegler terminal into a CP/M system. Microfit is a single-board 64K-byte computer using a Z80A processor and offering two RS-232C ports, a Centronics parallel interface, and a floppy-disk controller for up to four 5¼- or 8-inch disk drives. Storage capacities range from 200K bytes to 5 megabytes.

Microfit will convert Televideo Models 910, 912, 920, 925, and 950 terminals and Lear Siegler Models ADM-3A and ADM-5. It costs $1595, which includes CP/M and dual 720K-byte double-sided floppy-disk drives. Full details are available from Data Systems Marketing, 5710 Ruffin Rd., San Diego, CA 92123, (800) 854-2684; in California, (800) 532-3717.

Circle 664 on inquiry card.

Joystick for the Apple and IBM PC

The Mach III joystick from Hayes Products is connector-compatible with Apple II/IIe and IBM Personal Computers. It features a gimble with spring centering or free-floating in any or all four X,Y coordinates, which provides an arm alignment with 360° movement. Fire control buttons are located on the deck of the control unit and on the end of the joystick.

For the Apple II, the Mach III costs $49.95. The Apple IIe and IBM Personal Computer version is priced $5 higher. Contact Hayes Products, 1558 Osasge St., San Marcos, CA 92069, (714) 744-8546.

Circle 665 on inquiry card.

Synthesizer Creates Stereo Effect

The Stereo Composer is a music-synthesis system for the Radio Shack Color Computer and the TDP-100 from Speech Systems. Stereo Composer comes with software that lets you program four voices with a seven-octave range. Of the four voices, two are di-

rected toward two separate channels, creating a stereophonic effect. Dotted, double-dotted, eighth, quarter, and standard triplet notes are supported. Voices can be moved between speakers, and music can be played at any tempo in any key. Tempo and key can be changed as the music is playing. System hardware features individual 8-bit D/A (digital-to-analog) converters to drive two audio power amplifiers which, in turn, run a pair of loudspeakers. Output can be connected to a home stereo system for greater stereo effect.

The Stereo Composer costs $119.95. It's available from Speech Systems, 38 West 255 Deerpath Rd., Batavia, IL 60510, (312) 879-6880.

Circle 666 on inquiry card.

Printer Traveling Cases

Travelmaster's line of printer carrying cases features blow-molded double-wall construction, luggage-style handles, and locking latches. Cases are available for Epson Microlines, Okidata ML-80 series, C. Itoh Prowriter, and NEC 80-character printers. Suggested retail prices range from $79.95 to $94.95. For more information, contact Southern Case Inc., Travelmaster Division, 2315 Laurelbrook St., POB 28147, Raleigh, NC 27611, (800) 334-0551; in North Carolina, (919) 821-0877.

Circle 667 on inquiry card.

Programmable Robot Lifts More Than 1 Pound

The Microbot Alpha, a self-contained, programmable robot, can lift payloads of up to 1½ pounds. Alpha's arm, which has an 18-inch reach, offers such motions as 330° base rotation, 140° shoulder and elbow bends, 360° wrist rolls, and 180° wrist pitch. A cable-operated mechanical gripper uses timing belts coupled with metal pulleys to transmit the torque of stepper motors. Operating speeds as high as 20 inches per second are achievable, and Alpha can be programmed for acceleration and deceleration modes. Its repeatable position accuracy is plus or minus twenty-thousandths of an inch. An onboard computer can be set to retain 227 working positions. In addition, Alpha can be programmed with other computers through an RS-232C asynchronous serial interface using a proprietary programming language. It includes 4K bytes of EPROM and EEPROM and 1K bytes of RAM.

In single units, the Alpha robot costs $8500. More information is available from Microbot Inc., 435-H Ravendale Dr., Mountain View, CA 94043, (415) 968-8911.

Circle 668 on inquiry card.

Printwheel Cleaning System

Your printwheel's plastic and metal spokes and typeface crevices can be safely cleaned with the Copysource Printwheel Cleaning Kit. Spill-free wands are used to dispense 0.6 milliliters of a cleaning solvent that eliminates plastic glaze and dissolves caked magnetic dust, ink, and dirt.

Each self-contained Copysource kit contains 10 wands, 10 lint-free dry wipes, a cleaning station, and a tray. A single kit is $12.95. A case (10 kits) costs $89.50. *To order*, contact Chope-Stevens Paper Co., Department 202, 1800 18th St., Detroit, MI 48216, (313) 237-0300.

Circle 669 on inquiry card.

RS-232C Devices Aid Connections

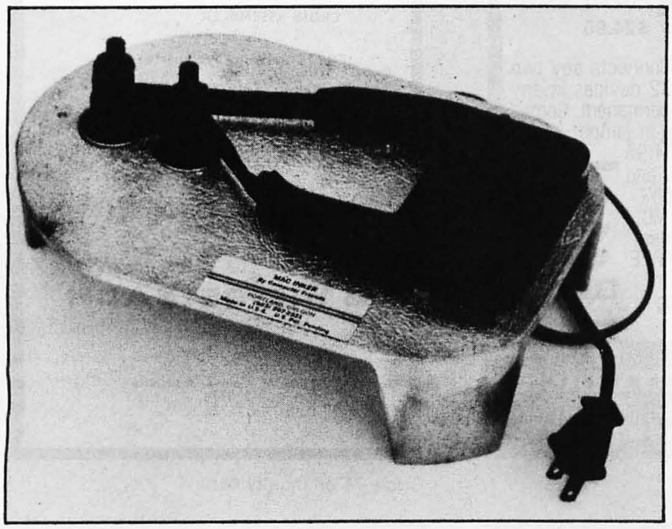
The Jaxon Division of RVR Systems markets two interconnection aids for RS-232C devices. The Owl inserts into any RS-232C port and indicates whether the device type is DTE (terminal) or DCE (modem). If left inline, the Owl indicates data transfers.

When inserted between RS-232C lines, the LBS-1 loopback switch lets you connect DTE to DTE, DCE to DCE, or DTE to DCE. Each connector operates LBS-1, except pins 2 and 3. It comes with descriptions of DATA, CONTROL, and TIMING lines.

These devices do not require power, nor will they load lines. The Owl costs $39.95. LBS-1 is $29.95. Both prices include shipping and handling originating from Jaxon, RVR Systems, POB 265, Dewitt, NY 13214.

Circle 670 on inquiry card.

What's New?

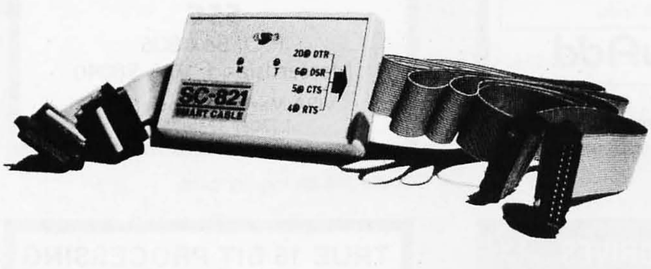


Automatic Ribbon Reinker

The Mac Inker from Computer Friends automatically reinks ribbons for any printer. Users merely load their ribbon cartridge, and Mac Inker metes out the correct amount of ink, evenly distributing it across the ribbon.

Mac Inker is available with multicolored inks and with cartridge-loading stations for most current printers. It costs $54.95. For full details, contact Computer Friends, 100 Northwest 86th Ave., Portland, OR 97229, (503) 297-2321.

Circle 671 on inquiry card.



RS-232C Cable Offers a Handshake to Any Peripheral

The SC821 Smart Cable from IQ Technologies is an intelligent RS-232C interface cable that can hook any computer to any peripheral with the flip of a single switch. This device is designed with onboard logic circuitry that determines which RS-232C interface lines are used by a computer and a peripheral, and it adjusts the handshaking signals accordingly. This eliminates the need for breakout boxes, cable redesign, and inventories of custom cables. Possible applications include system integration and field service.

The SC821 connects all the handshaking lines in a specific application in addition to CTS, DTS, DTR, and DSR. It functions at data rates of up to 19,200 bits per second. In the event of a hardware or software problem, the SC821's indicator lights point out the device that is disabling the data transfer. The cable is transparent to data rate, word length, and error and data codes. It costs $245 and can be ordered from IQ Technologies Inc., Suite 308, 11811 Northeast First St., Bellevue, WA 98005, (206) 451-0232.

Circle 672 on inquiry card.

Disk Storage Containers

Diskfiles provide efficient disk storage for up to 125 floppy disks. Disk compartments are separated by removable inserts, and five color-coded tab dividers are provided. The unit features dimensions similar to most disk drives and a dark, see-through acrylic finish.

Diskus Jr., which holds 75 disks, costs $39.95. Holding up to 125 disks, Diskfiles costs $59.95. An 8-inch version capable of handling 115 disks is $79.95. Add $3.75 shipping and handling to each order. Contact Diskus Products, 6003 Bandini Blvd., Los Angeles, CA 90040, (213) 726-3088.

Circle 673 on inquiry card.

Stand Lifts PC for Stowing Keyboard Safely

The P. C. Stand lifts the IBM Personal Computer so that you can safely stash the keyboard under the unit. The P. C. Stand allows the keyboard cable to be efficiently routed under the system, or it can be used for positioning the monitor at a more comfortable viewing height. This welded steel unit is finished to complement the IBM's color and texture. It measures 22 inches wide by 3 inches high by 14 inches deep. The suggested price is $34.95, plus $2 shipping and handling. The P. C. Stand can be ordered from Personal Computer Accessories, 4456 Partridge Court, San Jose, CA 95121, (408) 578-7798. ■

Circle 674 on inquiry card.

Where Do New Products Items Come From?

The information printed in the new products pages of BYTE is obtained from "new product" or "press release" copy sent by the promoters of new products. If in our judgment the information might be of interest to the personal computing experimenters and homebrewers who read BYTE, we print it in some form. We openly solicit releases and photos from manufacturers and suppliers to this marketplace. The information is printed more or less as a first-in first-out queue, subject to occasional priority modifications. While we would not knowingly print untrue or inaccurate data, or data from unreliable companies, our capacity to evaluate the products and companies appearing in the "What's New?" feature is necessarily limited. We therefore cannot be responsible for product quality or company performance.

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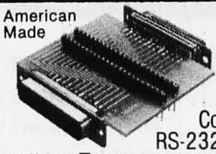

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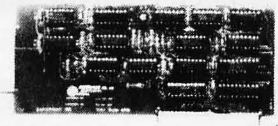

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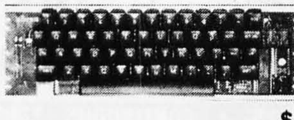

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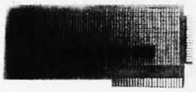

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General Products- cont.

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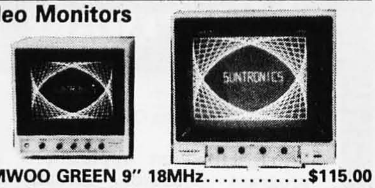

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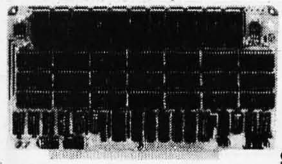
2532 (450nS)	5.95	5.95	4164	Call	Call
2764 (28 pin)	9.95	9.95	Z80A CPU	4.99	4.99

S-100 Products



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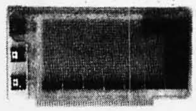

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74LS14	45	74LS92	.50	74LS160	.69	74LS247	1.10	74LS377	.95
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74LS20	24	74LS95	.65	74LS162	.69	74LS249	1.10	74LS379	1.10
74Ls21	20	74LS96	.89	74LS163	.85	74LS251	.55	74LS386	.45
74LS22	24	74LS107	.38	74LS164	.65	74LS253	.55	74LS390	1.15
74LS26	26	74LS109	.38	74LS165	.85	74LS257	.50	74LS393	1.15
74LS27	28	74LS112	.38	74LS166	1.75	74LS258	.55	74LS395	1.15
74LS28	28	74LS113	.38	74LS168	1.55	74LS259	1.25	74LS399	1.25
74LS30	24	74LS114	.38	74LS169	1.55	74LS260	.55	74LS490	1.75
74LS32	.27	74LS122	.45	74LS170	1.35	74LS266	.55	74LS623	1.75
74Ls33	.35	74LS123	.85	74LS173	.65	74LS273	1.45	74LS668	1.25
74LS37	.30	74LS125	.45	74LS174	.55	74Ls279	.45	74LS669	1.25
74LS38	.32	74LS126	.48	74LS175	.85	74LS280	1.85	74LS670	1.45
74LS42	.45	74LS132	.58	74LS181	1.95	74LS283	.65	74LS683	2.75
74LS48	.75	74LS133	.55	74LS190	.89	74Ls290	.95	74LS685	2.75
74LS49	.75	74LS136	.38	74LS191	.89	74LS293	.85	74LS687	3.50
74LS51	.24	74LS137	.85	74LS192	.75	74LS295	.95	74LS783	16.95
74LS54	.25	74LS138	.50	74LS193	.75	74LS298	.85		

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74S09	.35	74S65	.35	74S163	3.75	74S251	.85	74S374	2.45
74S10	.35	74S74	.50	74S174	.95	74S253	.85	74S387	1.90
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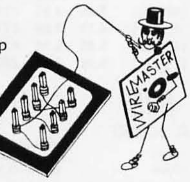

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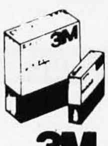

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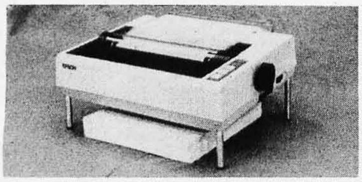

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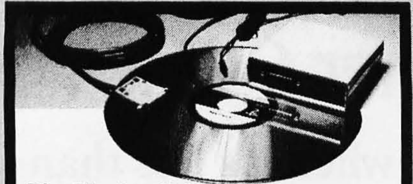

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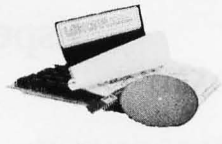

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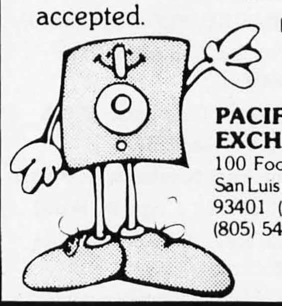

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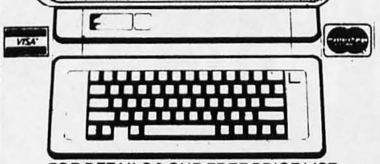

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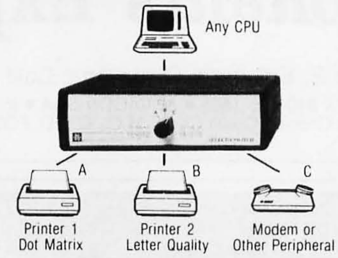

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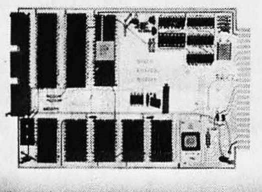

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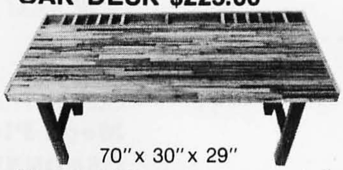

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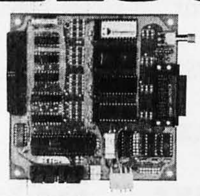

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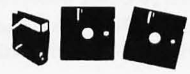

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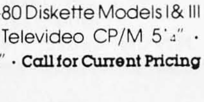

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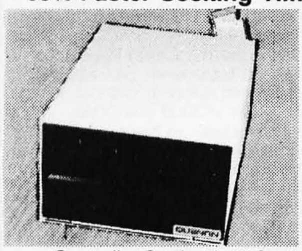

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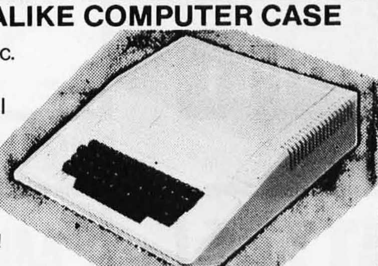

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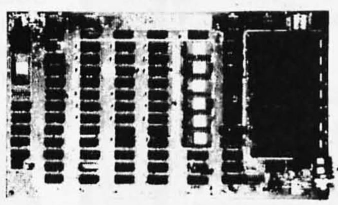

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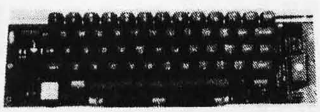

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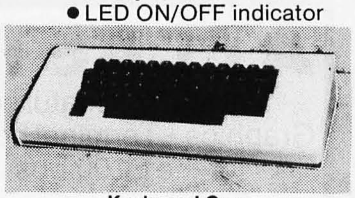

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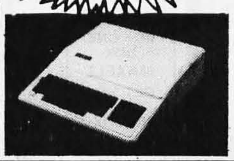

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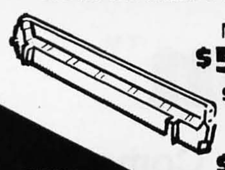

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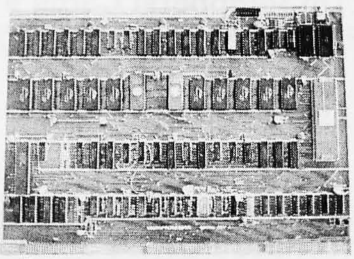

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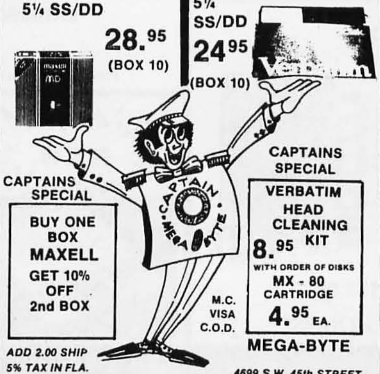

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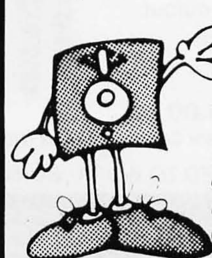

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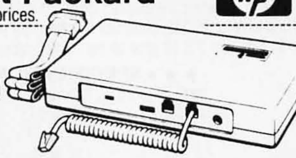

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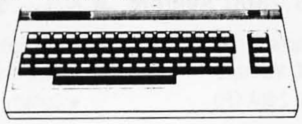

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Fast machine language graphics routines for PET/CBM	
RAM/ROM for PET/CBM — 4K $75 8K $90	
DISK ICU – Recovery System for PET/CBM	40

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Wabash 5" ss/dd	10/ 1.95	50/ 1.90	100/ 1.85
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C-10	10/ .61	50/ .58	100/ .50
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Battery back up Uninterruptible Power Supply with surge and noise filtering. The answer to your power problems.

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VOICE BOX Speech Synthesizer (Apple or Atari)	
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Many printers available (Gemini-Star, Brother, OKI, etc.)	
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ALL BOOK and SOFTWARE PRICES DISCOUNTED

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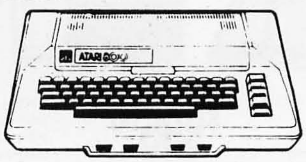

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WE STOCK ENTIRE LINE—write for prices.

Atari 1200	**CALL**	**QIX**	**34**
Voice Box	100	**Anchor Modem—Atari**	**79**
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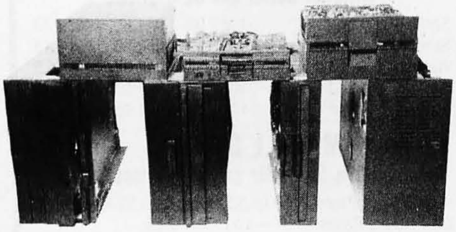

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8″ Tandon 848-1 Slimline SS/DD 600K BYTES	355.00
8″ Tandon 848-2 Slimline Double Sided 1.2 Meg.	475.00
8″ Siemens 100-8 SS/DD ON SALE NOW!!!	**169.00**
5¼″ Mitsubishi Full height 96T.P.I DS/DD 750K	295.00
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5¼″ Miniscribe 10 Meg* Thinline only 1½ inches wide!	**795.00**
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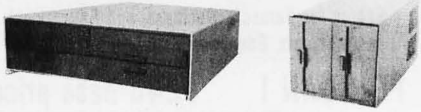
★LAST MINUTE SPECIAL!!! Buy any Winchester hard disk drive above and get a Western Digital hard disk interface board AT COST! .... ONLY 295.00!

*Total storage space after formatting.

DUAL DRIVE SUBSYSTEMS



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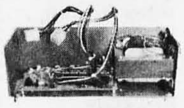
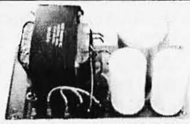
w/two Qume DT-8 DS/DD Assem. + Tested	1250.00
Cabinet A & T w/Power Supply and Accs.	235.00
Cabinet Top and Bottom	*Only* 69.50

All cabinets A & T and subsystems include all AC/DC wiring and 50 pin data cable except the horizontal model which includes the internal 50 pin cable and requires an external 50 pin cable part #C-6000-01 .... $ 25.00

5¼″ Subsystems

w/two 48TPI SS/DD includes all cables	495.00
w/two 48TPI DS/DD includes all cables	595.00
w/two 96TPI DS/DD includes all cables	695.00





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+5VDC @ 4 Amps
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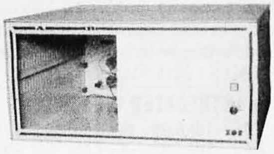
- Built-in Speaker for Monitoring Call Line

These are just a few features of the Smartmodem 1200, the best modem you can buy, in fact, it performs just about any communication function you can imagine, and can be program controlled using any language. Our special price $549.00
★Make things easy for yourself. Get the Hayes Smartmodem 1200 with CROSSTALK™ software $629.00

FANTASTIC SAVINGS! $395



ON THE ORIGINAL S-100 MOD

For engineers, hobbiests, and anyone who wants to save a bundle, the S1-MOD is the answer. Full regulated power to run up to four floppy disks coupled with a mamoth S-100 power supply and 12 slot bus, makes the S1-MOD an exceptional computer base. Single board design means no wiring from the power suppply to the motherboard. This eliminates all ground loop problems associated with other brands of mainframes who are forced to use termination. The S1-MOD is being offered this month with a matching S-100-12 cabinet. Fan cooled, fused, with reset and keylock the cabinet is also enamel painted and silk screened. Four A.C. outlets are provided for peripheral hookup and plenty of cutouts available for RS-232, centronics + others. Our regular $225.00 price for the S1-MOD and 250.00 price for our 12 slot cabinet is being SLASHED!

★ ★ ★ SPECIFICATIONS ★ ★ ★

Input	Regulated	Unregulated
120V/60HZ.	+5V @ 5A	+8V @ 30A
230V/50HZ.	+24V @ 3A	±16V @ 6A
	–5V @ 1A	

Don't settle for those cheap 6 slot immitations you've seen elsewhere in this mag. OWN THE BEST! XOR S-1 MOD and S-100-12 Cabinet ..... **$395.00!**

California Computer Systems

CCS SYSTEM 2410 . . $1995.00

- ★ Includes CP/M® 2.2
- ★ 2-Serial/1-Parallel Port
- ★ DMA Disk Controller
- ★ Hardware Vectored Interrupts
- ★ 2-Real Time Clocks.
- ★ Supports CP/M®, MP/M®, OASIS

CCS 2300 System, A & T . . $1695.00

- ★ Includes CP/M® 2.2
- ★ New 2066 64K Memory
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★ 2710 4 Port Serial	$245.00
★ 2719 2 Serial – 2 Parallel	245.00
★ 2810 CPU Z-80 at 4 MHz	*Only*–255.00
★ 2422 Disk Controller with CP/M 2.2	*Only*–330.00
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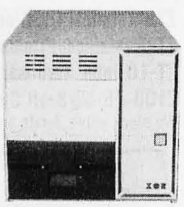
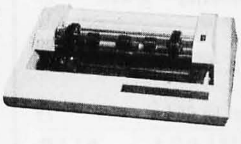
MICRO COMPUTERS FOR MICRO$DOLLARS





XOR 500

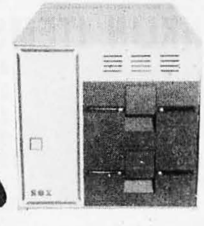
A matching terminal with a detachable keyboard and green screen for under $500.00? See description on opposite page.

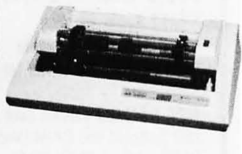
$995.00

SEIKOSHA – Meaning high quality and low cost in a dot matrix design. Full Graphics, parallel interface, 80 column, double width print, and automatic printing make this printer a "Best buy." Quality? you bet, and backed by a two year end user warranty
Seikosha GP-100A, 2 year warranty **$239.00**

A computer for under 1,000 dollars? YES, U.S. MICRO SALES is offering for limited time only, a 4 slot-S-100 bus computer system at $995. Full 64K of memory means there's no need to add any memory. With 64K and CP/M 2.2 operating *system (included)* you're able to run over two thousand different software application packages. Formats? This little system will read MORROW, IBM, KAYPRO, and XOR Formats. The disk controller is so advanced it can write any byte/size sector, single or double sided single or double density AND....it runs both 8″ and 5¼″ drives! If more storage is needed, add on an 8″ subsystem and you'll be able to READ AND WRITE the IBM 3740 Format – an industry standard. The system *above includes* 5¼″ floppy storage, 4 slot S-100 bus, 3 board set with Z-80A @ 4MHz., 2 serial RS-232 ports, Centronics parallel port and two whole diskettes full of free utility software along with CP/M 2.2.

S-100-4 Mini 5¼″ System #S-1000-83 .... **$995.00**
Limit 1 to a customer – offer expires Sept. 15th 1983





XOR 500

A new video display terminal featuring ★ screen tilt ★ detached keyboard ★ 9 cursor control keys ★ 5 function keys ★ 7 screen attributes ★ 25th status line ★ 50-19.2K baud ★ column + field tab ★ and more ★ All these features with a full 6 month warranty make this terminal the best buy on the market.
XOR 500, #T-1000-15 .... **$495.00**

HARD DISK $1995.00

Once again Seikosha has come out with a fantastic buy! The GP-250X. For starters, there is memory set aside for you to define 64 of your own characters or symbols. There's more memory for storing your own print sequences, up to four of them. BOTH serial and parallel interfaces – STANDARD. Self test mode – STANDARD. Graphics, double width and/or double height characters – STANDARD.
SEIKUSHA GP-250X, 2 year warranty **$295.00**

At the price of a hard disk subsystem, this expandable, upgradeable hard disk microcomputer is obviously a "BEST BUY". Z-80A based at 4 MHz. with 64K of dynamic memory and CP/M 2.2 allows you to run thousands of available software programs. A full 5 megabytes of formatted storage provides plenty of storage for programs and data. High speed data transfer is accomplished with a Western Digital hard disk controller. Our on board prom monitor allows booting up CP/M from the floppy or hard disk. Factory direct delivery gives you factory direct service if it is ever needed. The hard disk system is available in many different configurations should you require 3 or 4 floppys or a large hard disk. The readable formats for this system now include: IBM, MORROW, KAYPRO and XOR. Adding a pair of 8″ drives is no problem as the software you receive will also have 8″ format-copy read and write files. The XOR disk controller will run both 8″ and 5¼ floppys simultaneously giving you the ability to read + write the IBM 3740 format, an industry standard. Features also include... two separate power supplies, a 5 board set, an S-100 bus structure, serial and parallel ports and a spare S-100 slot for your own expansion. All this gives the XOR S-100-4 hard disk system the qualities needed to remain a step ahead in the microcomputer industry.

XOR S-100-4 Hard Disk #S-1000-89 .... **$1995.00**
Limited quantities – one per customer – expires 9/15/83

See Page 291 for Additional System Information

Circle 401 on inquiry card.

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OUR BEST SELLING TERMINALS

Adds Viewpoint: A low cost high performance terminal w/green screen and detachable keyboard. Features include ★ Reverse video ★ half intensity ★ Visual highlighting ★ Full auxiliary port use ★ 150 — 19.2K baud rate ★ Screen tilt ★ Foreign language international character set ★ 4 way cursor setting ★
ADDS VIEWPOINT #T-1000-04 .... **$519.00**

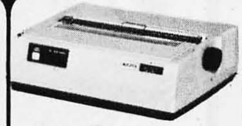
Televideo 910+: Save your eyes on a great green screen w/features like ★ Built-in self test ★ Full editing ★ Tab options ★ cursor control ★ 16 visual attributes like, reverse video, monitor mode, half intensity and block or underline, blink or steady cursor ★ Full numeric keypad ★ 925/950 emulation ★.
TELEVIDEO 910+ #T-1000-05 .... **$569.00**

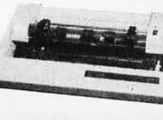
XOR 500: A new video display terminal featuring ★ Screen tilt ★ Detached keyboard ★ 9 cursor control keys ★ 5 function keys ★ 7 screen attributes ★ 25th status line ★ 50-19.2K baud ★ Column + field tab ★ and more ★ All these features with a full 6 month warranty make this terminal the best buy on the market.
XOR 500 #T-1000-15 .... **$495.00**

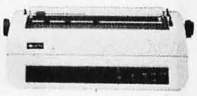
Televideo 925: From the hobbyist to the basic professional this popular terminal will fit your needs. ★ Detachable keyboard ★ Numeric keypad ★ Green screen ★ Self test ★ Time of day display ★ Programmable function keys ★ 912/920 emulation hardware/software programmable configurations ★ Extra memory page ★ Four switchable foreign languages ★ Tilt screen ★ 25th status line ★
TELEVIDEO 925 #T-1000-08 .... **$739.00**

TELEVIDEO 950 #T-1000-09 .... **$939.00**

PRINTERS
NEW ARRIVALS! NEW MODELS!







Mannesman Tally MT 180 — IN STOCK!!!! New design and technology with a price tag that will knock your socks off. The MT-180 is the most sought after printer currently on the market. This printer is the answer to all your printer needs. You get high resolution business graphics, outstanding letter quality text for word processing, and continuous high speed report printing! Eight letter widths give your printout a change of pace. On the 132 column width condences 264 columns. The dual shift print head with a 20 x 18 matrix prints outstanding letter quality type. So good you'll think you invested in a daisywheel. Not convinced? Serial and parallel hookup — STANDARD. 96 characters ASCII draft quality. 96 characters letter quality. 11 graphic symbols, 31 Greek characters, 6 foreign languages, bi-directional logic seeking dual shift printhead. AND ... Program by menu! Ever tried to figure out the switch settings on a printer? The MT-180 has push button "PROMPT" programming. Answer questions YES or NO to set up formats & character sets, & communications with your printer! The last feature is the reason you'll soon own an MT-180 ...... THE PRICE **$995.00**

Okidata Microline: New versatility, correspondence quality printing and speed make the ML92 and ML93 the best printer values in their categories. Both printers provide multi-speed print modes; bi-directional high speed mode with short line seeking logic at 160cps, emphasized and enhanced mode printing at 80cps, and high resolution correspondence quality printing at 40cps. Dot-addressable graphics is standard. Both serial and parallel models are available and **BOTH prices include** full tractor assembly at no extra charge.
ML92 (Serial Add $85) #M-2000-10 .... **$ 629.00**
ML93 (Serial Add $85) #M-2000-11 .... **$ 965.00**

Seikosha — Meaning high quality and low cost in a dot matrix design. Full graphics, parallel interface, 80 column, double width print, and automatic printing make this printer a "Best buy". Quality? you bet, and backed by a two year end user warranty.
Seikosha GP-100A 2-year warranty **$239.00**

Daisywriter 2000. An innovation in daisywheel letter quality. Printwheel cassettes, first introduced by Daisywriter, are enclosed printwheels to prevent damage or breakage of those costly daisy wheels. These cassettes are available in 14 print styles and 16 languages. Over 75 software commands makes word processing easy. Almost a word processor in itself! AND standard serial interfacing, 16K (48K optional) buffer. That's right sixteen K of memory allow you to "spool" to the buffer in less than a second and print for up to an hour with optional low cost sheet feeder or tractor. PLUS automatic margin, auto proportional spacing, Daisyplot™ graphics with absolute and relative vector plotting, auto baud rate, self test, 132 to 264 column print, full line spacing an MORE! Need to print 3 or 4 part forms? No problem as the D-2000 handles the original and up to 7 copies. Don't feel you'll be getting stuck with a low speed letter quality printer — 200 CPS high speed "white space" printing will get that 30 page report out in no time.
Daisywriter 2000 .... **$1150.00**

The 4 slot S-100 systems below are equipped with **XOR** Z-80 4MHZ three board set. Each can run 8″ or 5″ disk simultandously. In addition to the high speed **XOR** mini format, they can read KPRO, IBM and Morrow 5″ disk formats. Each has a modular dual power supply sub chassis. They are fan cooled. Standard I/O is 2 serial ports and one centronics parallel. Expansion I/O is available.

MICRO MANAGER TWIN 5¼″ MINI

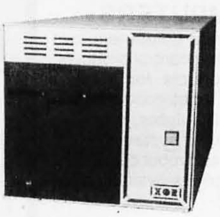
Don't be fooled by this system's small portable size.

- Full 64K of memory with an industry standard S-100 bus
- Includes CP/M 2.2 and many utilities on two disks
- Add on a hard disk when you need more storage

★ ★ COMPLETE SYSTEMS ★ ★

Dual Floppy 368K SS/DD **$1445.00**
Dual Floppy 750K SS/DD **$1595.00**
Dual Floppy 1.5 Meg DS/DD **$1645.00**
Chassis (No boards No drives) .... **$ 425.00**

MICRO MANAGER MINI HARD DISK SYSTEMS

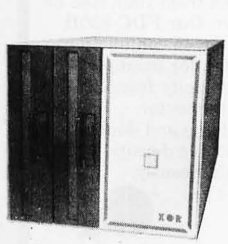


Inexpensive but powerful, small enough for portability, these mini hard disk systems have a special XOR interface to the S-100 bus that leaves an S-100 slot open for expandability. Choose from 5, 10, and 16 megabyte sizes (6.5, 12, + 20 megabyte unformatted.)

5 Megabyte Hard Disk w/750K Floppy **$2345.00**
10 Megabyte Hard Disk w/750K Floppy **$2475.00**
16 Megabyte Hard Disk w/750K Floppy **$2545.00**

Many Other Configurations Available — Ask Us!

8″ MICRO MANAGER

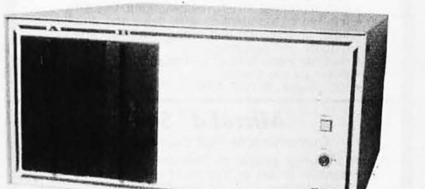


Our most popular computer features a 4 slot S-100 bus and 8″ industry standard format. Reads and writes the IBM 3740 format as well as any byte/size sector. Expandable? Yes, add a hard disk or cartridge subsystem when your data base grows, includes CP/M.

★ System with SS/DD 1.2 Megabytes **$1795.00**
★ System with DS/DD 2.4 Megabytes **$1995.00**
★ System with NO Drives (includes CP/M) **$1195.00**
★ System Chassis (No boards, no drives, no CP/M) **$ 395.00**

The 12 slot commercial grade S-100 systems below have all of the features listed above plus a massive 30 amp power supply capable of the expansion we expect you will do. All units are cooled by four inch fans. Each system must pass 2 days of constant read and write disk testing without a single error before shipment. ***One year complete warranty is included.***

BASIC PROFESSIONAL



★ w/2 SS/DD 1.2 Megabytes **$2295.00**
★ w/2 DS/DD 2.4 Megabytes Full Ht. or Slimline ... **$2345.00**

Buy the basic professional with thinline drives if you plan to upgrade to a hard disk in the future.

★ System w/no Drives (Includes CP/M) **$1350.00**
★ 12 Slot Chassis w/no Boards, Drives, or CP/M .. **$ 495.00**

OFFICE MASTER REMOVEABLE CARTRIDGE DISK SYSTEM

Your storage problems have been solved! Two 10 megabyte IOMEGA removeable cartridge drives with the speed and reliability of a hard disk means you NEVER run out of storage. Just pop in another 10 meg cartridge. Imagine 20, 50 over 100 megabytes of data at your fingertips. All systems include 2 cartridges and CP/M 2.2 operating system.

Good ★ 10 Meg Removeable cartridge w/1.2 meg Floppy **$3695.00**
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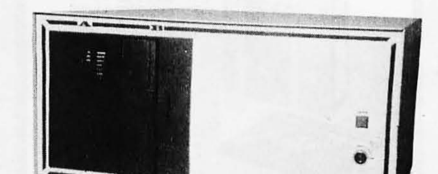

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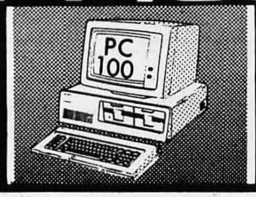

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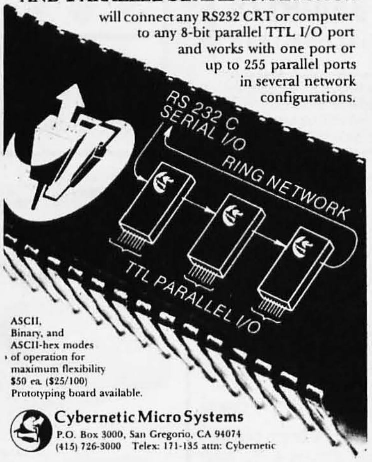

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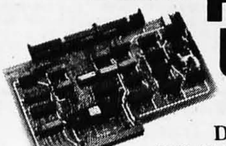

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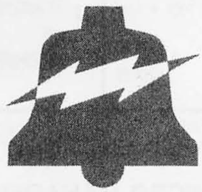

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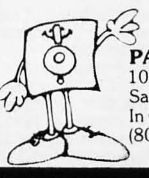

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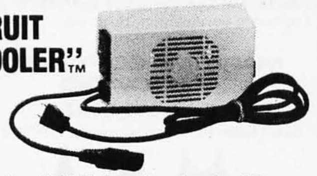

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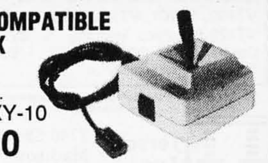

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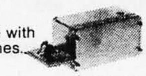

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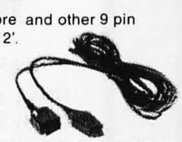

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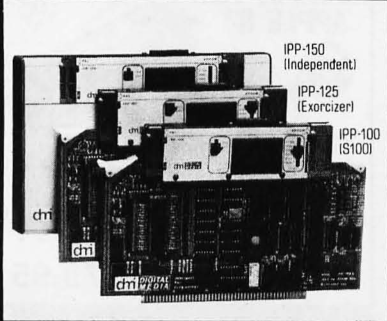

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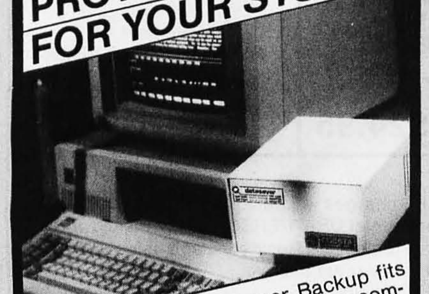

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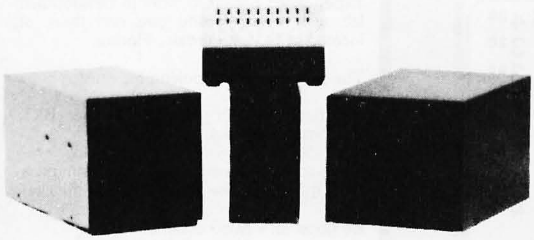

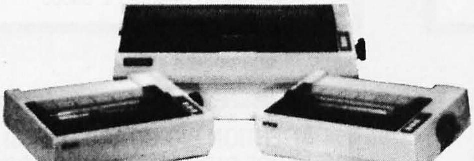

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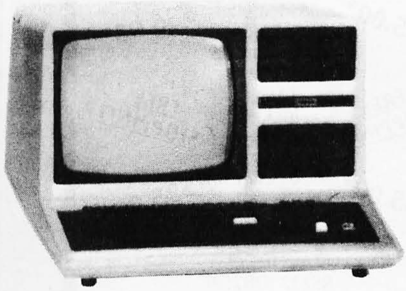

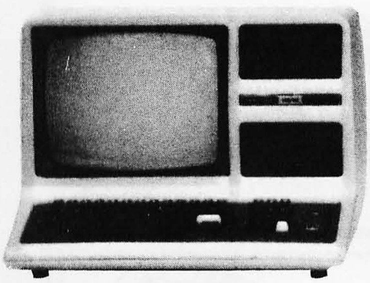

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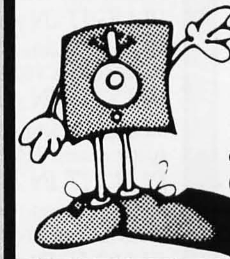

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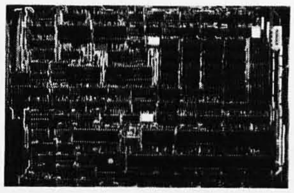

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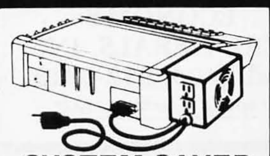

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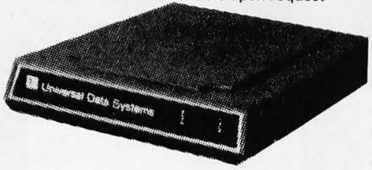

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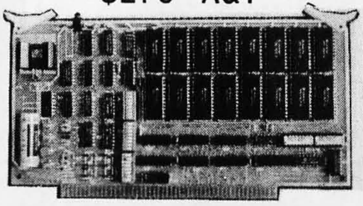

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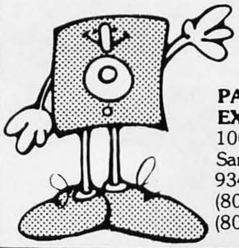

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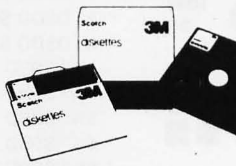

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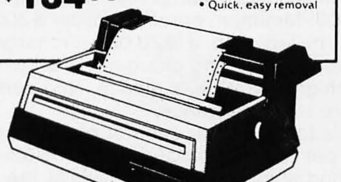

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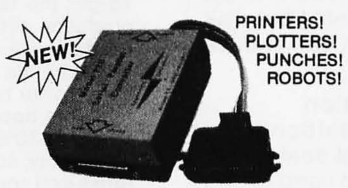

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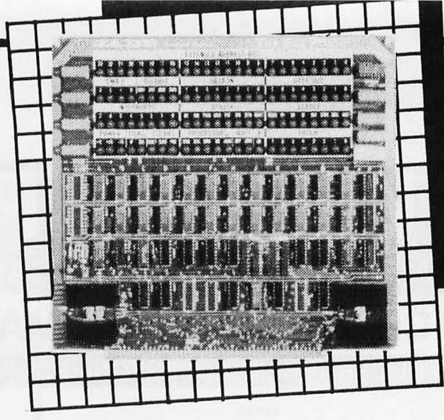

S-100 MEMORY BOARDS

64K STATIC RAM - Jade

Uses new 2K x 8 static RAMs, fully supports IEEE 696 24 bit extended addressing, 200ns RAMs, lower 32K or entire board phantomable, 2716 EPROMs may be subbed for RAMs, any 2K segment of upper 8K may be disabled, low power typically less than 500ma.

MEM-99152B	*Bare board*	$49.95
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MEM-32152K	*32 kit*	$199.95
MEM-56152K	*56K kit*	$289.95
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EXPANDORAM III

SD Systems new ExpandoRAM III is a high density S-100 memory board utilizing the new 64K x 1 dynamic RAM chips. It allows memory sizes of 64K, 128K or 256K all on a single S-100 board.

MEM-65064A	*64K*	$495.00
MEM-65128A	*128K*	$595.00
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PRA-61000	*Tractor option*	$139.95

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PRD-11300	*380Z printer*	$1295.00
PRA-11000	*Tractor option*	$169.95
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2 serial I/O ports plus 2 parallel I/O ports

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IOI-1015A	*A & T*	$289.95

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PB-1 — SSM Microcomputer

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PROM-100 — SD Systems

2708,2716, 2732 EPROM programmer with software

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DISK Sub-Systems — Jade

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END-000434	*A & T w/2 Shugart SA-801Rs*	$1195.00

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MBS-121A	*A & T*	$109.95

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MBS-181A	*A & T*	$149.95

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CPU-30200A	*A & T*	$329.95

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Dual 8" Slimline Sub-Systems

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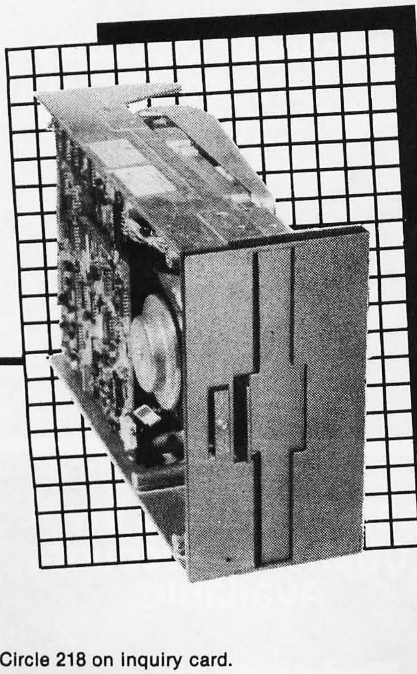

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74LS01	.23	74LS124	2.88	74LS257	.57
74LS02	.23	74LS125	.47	74LS258	.57
74LS03	.23	74LS126	.47	74LS259	2.73
74LS04	.23	74LS132	.57	74LS260	.57
74LS05	.23	74LS136	.37	74LS266	.53
74LS08	.23	74LS137	.97	74LS273	1.47
74LS10	.23	74LS138	.53	74LS275	3.33
74LS11	.25	74LS139	.53	74LS279	.47
74LS12	.25	74LS145	1.18	74LS280	1.96
74LS13	.39	74LS147	2.47	74LS283	.67
74LS14	.39	74LS148	1.33	74LS290	.87
74LS15	.29	74LS151	.53	74LS293	.87
74LS20	.23	74LS153	.53	74LS295	.97
74LS21	.23	74LS154	1.88	74LS298	.87
74LS22	.23	74LS155	.67	74LS324	1.73
74LS26	.29	74LS156	.67	74LS352	1.27
74LS27	.23	74LS157	.63	74LS353	1.27
74LS28	.29	74LS158	.57	74LS363	1.33
74LS30	.23	74LS160	.67	74LS364	1.93
74LS32	.25	74LS161	.63	74LS365	.47
74LS33	.49	74LS162	.67	74LS366	.47
74LS37	.29	74LS163	.63	74LS367	.43
74LS38	.29	74LS164	.67	74LS368	.43
74LS40	.23	74LS165	.93	74LS373	1.37
74LS42	.43	74LS166	1.93	74LS374	1.37
74LS47	.49	74LS168	1.73	74LS377	1.37
74LS48	.74	74LS169	1.73	74LS378	1.17
74LS49	.74	74LS170	1.47	74LS379	1.33
74LS51	.23	74LS173	.67	74LS385	1.88
74LS54	.23	74LS174	.53	74LS386	.43
74LS55	.28	74LS175	.53	74LS390	1.17
74LS63	1.23	74LS181	2.13	74LS393	1.17
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74LS74	.33	74LS190	.87	74LS399	1.47
74LS75	.37	74LS191	.87	74LS424	2.93
74LS76	.37	74LS192	.77	74LS447	.35
74LS78	.47	74LS193	.77	74LS490	1.93
74LS83	.58	74LS194	.67	74LS668	1.67
74LS85	.67	74LS195	.67	74LS669	1.87
74LS86	.37	74LS196	.77	74LS670	1.47
74LS90	.53	74LS197	.77	74LS674	9.63
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74LS92	.53	74LS240	.93	74LS683	3.18
74LS93	.53	74LS251	.59	74LS684	3.18
74LS95	.73	74LS242	.97	74LS685	3.18
74LS96	.87	74LS243	.97	74LS688	2.38
74LS107	.37	74LS244	1.27	74LS689	3.18
74LS109	.37	74LS245	1.47		
74LS112	.37	74LS247	.73	81LS95	1.47
74LS113	.37	74LS248	.97	81LS96	1.47
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2.4576	2.69	14.31818	2.69
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Flip & File 8" stores 50 disk	INC-800	22.85
Scotch head clean kit 5¼ & 8	MMM-ck5	24.95
Plastic library cases 5¼ & 8"	SRW-L5	2.95

Single Side Double Density

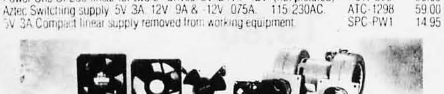
SCOTCH	741-0	39.00
MEMOREX	3090	35.00
DYSAN	3740/D	57.50

Double side Double Density

SCOTCH	743-0	47.50
MEMOREX	3114	39.50
DYSAN	3740/2D	65.00

POWER SUPPLIES & FANS

S-100 supply, toroid transformer. 8V 30A, ±16V 5A. AC receptacle	EDP-P100	119.00
Calif DC switching supply for 5¼" Winchester or 8" drive 12/24 volt & 5V.	CAD-53010	119.00
Power One CP206 linear for two 8" drives. 5V, 24V, -12V (not pictured)	POW-206	99.00
Aztec Switching supply. 5V 3A, 12V 9A & -12V .075A. 115/230AC.	ATC-1298	59.00
5V 3A Compact linear supply removed from working equipment	SPC-PW1	14.95



Dual squirrel cage blower flange mounted. 115v 92watts 200 cfm	UEC-1087	19.95
Pamotor 4600X 4½" fan, all metal construction, 115v 20 watts 85 cfm.	PAM-4600	14.77
ETRI 141LV-2182 4½" fan, metal construction, 115v, 9 watts 45 cfm	ETR-2182	14.77
Rotron Muffin fan 4½" open frame construction, 115v 14 watts 65 cfm	ROT-M2A2	9.95
ETRI 126LF-2182 3¼" fan, Aluminum construction, 115v 9 watts 35 cfm	ETR-126	14.77

MEMORY

16K DYNAMIC	2732 EPROM
1.95	**4.95**
4116 150ns.	450ns.
64K DYNAMIC	**16K STATIC**
6.95	**4.95**
4164 150ns.	6116 200ns.

2764 EPROM SALE $5.95

DYNAMIC MEMORY

		1-31	32+	100+
4027 4K dynamic 250ns.	ICM-4027250	1.99	1.85	1.75
4116 150ns. 16K	ICM-4116150	1.95	1.85	1.75
4116 200ns. 16K	ICM-4116200	1.75	1.65	1.50
4164 150ns. 64K 128 refresh	ICM-4164150	6.95	6.50	5.90
41256 150ns. 256K	ICM-41256150			

STATIC MEMORY

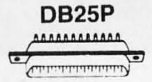
21L02 200ns. 1K static	ICM-21L02200	1.49	1.29	1.15
21L02 450ns. 1K static	ICM-21L02450	1.29	1.15	.99
2112 450ns. 2K static	ICM-2112450	2.99	2.85	2.75
2114 300ns. 1K x 4	ICM-2114300	1.95	1.85	1.75
4044TMS 450ns. 4K x 1	ICM-4044450	3.49	3.25	2.99
5257 300ns. 4K x 1	ICM-5257300	2.50	2.25	1.99
6116 P4 200ns. 2K x 8	ICM-6116200	4.95	4.80	4.65
6116 P3 150ns. 2K x 8	ICM-6116150	5.95	5.75	5.60
6167/2167 100ns. 16K x 1 (20 pin)	ICM-6167100	8.95	8.50	7.90

EPROMS

2708 450ns. 1K x 8	ICE-2708	4.95	4.75	4.55
2716 450ns. 2K x 8	ICE-2716	4.95	4.75	4.55
2716TMS 450ns. Tri-voltage	ICE-2716TMS	7.95	7.65	7.25
2732 450ns. 4K x 8	ICE-2732	4.95	4.75	4.55
2732 350ns. 4K x 8	ICE-2732350	8.50	8.00	7.60
2532 450ns. 4K x 8	ICE-2532	10.50	9.90	9.50
2764 350ns. 8K x 8	ICE-2764	5.95	5.65	4.97
27128 350ns. 16K x 8	ICE-27128	29.95	28.32	27.46

CONNECTORS

S-100 Gold
$2.95



DB25P
$2.50

GOLD S-100 EDGE CARD CONNECTORS

	catalog	each	10-99	100+
Imsai s/t .250"	CNE-IMS	2.95	2.50	2.19
Sullins Hi/Rel	CNE-H100	4.19	3.85	3.47
S-100 Wire W.	CNE-W10	3.95	3.50	3.19
Altair .140" s/t	CNE-100A	4.95	4.50	4.19

.156" CENTER EDGE CARD CONNECTORS

22/44 Eyelet	CNE-44E	2.50	2.15	1.95
43/72 Moto. s/t	CNE-72S	6.60	6.15	5.75
36/72 D/G s/t	CNE-72S	5.95	5.50	5.19

Other connectors available upon request

RIBBON CONNECTORS

DB25P male	CND-r25P	5.65	5.25	4.15
DB25S female	CND-r25S	5.95	5.59	4.50
57-30360 male	CNC-r36P	7.95	6.75	5.90
57-30360f male	CNC-r36S	7.95	6.75	5.90
20 pin edge	CNI-DE20	4.35	3.30	2.50
20 pin socket	CNI-DS20	2.75	1.85	1.60
26 pin edge	CNI-DE26	4.95	3.50	2.70
26 pin socket	CNI-DS26	3.50	2.40	2.15
34 pin edge	CNI-DE34	4.95	4.50	3.50
34 pin socket	CNI-DS34	4.50	3.95	3.15
50 pin edge	CNI-DE50	5.95	5.60	4.90
50 pin socket	CNI-DS50	4.95	4.60	3.80

"D" TYPE	catalog	each	10-99	100+
DE9P male	CND-9P	1.60	1.40	1.30
DE9S female	CND-9S	2.25	2.00	1.30
DE hood	CND-9H	1.50	1.35	1.20
DA15P male	CND-15P	2.35	3.10	2.90
DA15S female	CND-15S	3.25	3.10	2.90
DA15 hood	CND-15H	1.60	1.35	1.30
DB25P male	CND-25P	2.50	1.95	1.65
DB25S female	CND-25S	3.35	2.75	1.95
DB25 hood	CND25H	1.35	1.15	.77
DC37P male	CND-37P	4.20	3.95	3.65
DC37S female	CND-37S	5.95	5.75	5.50
DC37 hood	CND-37H	2.25	1.95	1.65
DD50P male	CND-50P	5.50	5.10	4.75
DD50 hood	CND-50H	2.60	2.40	2.10
Hardware 2/set	CND-2HS	.99	.69	.42

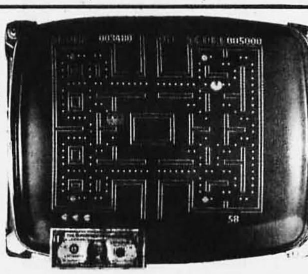
AMPHENOL / CENTRONICS TYPE

57-30360 36/P	CNC-36P	7.95	6.35	4.90
IEEE488, C'dor	CND-24P	7.95	6.35	5.35

DISK DRIVE POWER CONNECTORS

8" 6 pin D.C.	CNP-6DC	1.95	1.29	.89
8" 3 AC Sgl/S	CNP-3SS	1.69	1.09	.69
8" 3 AC Dbl/S	CNP-3DS	1.69	1.09	.69
5¼" 4 pin D.C.	CNP-4DC	1.79	1.19	.99
3 pin DIN recpt.	CNP-D3P	2.59	1.99	1.59

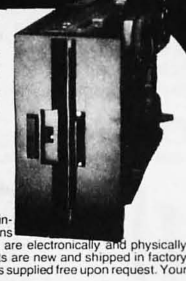
23" COMPOSITE MONITOR $159



Ideal monitor for classroom demonstrations.

Ever try gathering a classroom of students around a 12" monitor? Here is your opportunity to purchase a 23" high resolution monitor at a reasonable price.
These units accept standard composit video signals generated by most personal computers including the Apple and IBM. Attach it your computer and in second you are shooting down Klingons in wide screen video.
MOT-BW23 35 Lbs. Monitors are open frame and for safety should be enclosed. Wood grained enclosure for above $35.00 additional CAL-ENC23 15 Lbs.

BLOWOUT SALE $179



California Digital has recently participated in the purchase of several thousand Siemens FDD 100-8 floppy disk drives. These units are electronically and physically similiar to that of the Shugart 801R. All units are new and shipped in factory sealed boxes. Manual and power connectors supplied free upon request. Your choice 115 Volt. 60 Hz. or 230 Volt. 50Hz.

NOTE! European customers, we have a large quantity of 230 volt 50 Hz. units warehoused in Frankfort Germany. Arrangements can be made to will call these drives in quantities of 50 or more in Frankfort reducing import duty and freight charges.

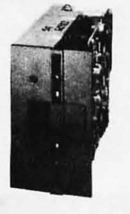
REMEX DOUBLE SIDED $219

California Digital has just purchased a large quantity of Remex RFD-4000 **Eight inch double sided** disk drives. Remex is the only double sided disk drive that has an double gimbal mounted head assembly that guaranties lower head tracking. This drive is mechanically solid. Remex has always been known for producing premiere products for the floppy disk market. The Remex company is a subsidiary of the Ex-cell-o Corporation, a Fortune 500 Company.

	One	Two	Ten
Eight Inch Single Sided			
SHUGART SA801R	$395	385	375
SIEMENS FDD100-8	179	179	169
TANDON 848-1 SLIMLINE	369	359	349
Eight Inch Double Sided			
SHUGART SA851R	525	495	475
QUME DATA TRACK 8	525	495	475
MITSUBISHI M2894-63	459	449	409
REMEX RFD-4000	219	209	189
TANDON 848-2 SLIMLINE	485	475	465
SHUGART 860 THINLINE	569	549	539
Five Inch Single Sided			
SHUGART SA200 ⅔ Height	169	159	149
TANDON TM 100-1	119	119	Call
Five Inch Double Sided			
SHUGART SA455 ½ Height	259	249	239
SHUGART SA465 96TPI	289	279	269
TANDON TM 100-2	279	269	259
TANDON TM 101-4 96TPI	369	355	350
Three Inch Rigid Floppy			
HITACHI-AMDEK	call for pricing		
Five Inch Winchesters			
SEAGATE 406 6 Megabyte	695	675	650
SEAGATE 412 12 Megabyte	995	960	960
TANDON TM-503 14 Megabyte	895	860	795
WESTERN DYNAX removable	995	960	950

Upon request, all drives are supplied with power connectors and manual

SPECIAL Tandon TM 100-1 $119



Recent liquidation from a major manufacturer of data processing equipment allows California Digital the opportunity to offer these Tandon disk drives at a fraction of their original cost. Brand new, with 90 day guarantee. TAN-TM1001

VISA
master charge

Shipping: First five pounds $3.00. Each additional $.50.
Foreign orders: 10% shipping. Excess will be refunded.
California residents add 6½% sales tax. COD's discouraged.
Open accounts extended to state supported educational institutions and companies with a "strong" Dun & Bradstreet.
Warehouse: 15608 Inglewood Blvd.

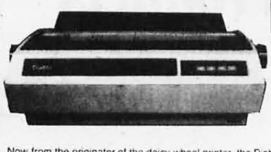
TOLL FREE ORDER LINE
(800) 421-5041
TECHNICAL & CALIFORNIA
(213) 679-9001

California Digital

Post Office Box 3097 B • Torrance, California 90503

LIBERTY FREEDOM 50 $475

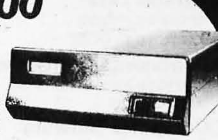
The Liberty Freedom 50 terminal features detachable keyboard with 93 keys including 10 function keys, 15 graphic symbols, and DIP switch selectable character set for 7 foreign languages. The 12 inch etched non-glare green phosphor screen displays 24 rows by 80 characters in 7x9 matrix with true descenders. Self test and 25th data display row also included. Switch selectable baud rates from 110-19,200 baud. Screen attributes do not use display memory, allowing operator to display a full 1920 characters. Emulates 5 popular CRT terminals for easy software configuration. Switch selectable between 115 and 230 volt. We have never seen a terminal with all these features for the incredibly low price of only $475. LIB-F50 40 lbs.



DIABLO Word Processing Printer $879

Now from the originator of the daisy wheel printer, the Diablo 620. Print speeds to 24 char/sec., user selectable bi-directional printing, superscripts, subscripts, graphics and more. Plus standard RS-232 interfacing. Communication speeds to 1200 baud with a 1500 character print buffer. Software programable absolute horizontal tabs makes report formatting easy. Over 20 different print wheels are currently available. The 620 automatically selects the print spacing for 10, 12, 15 char/inch print wheels. On site service available worldwide. DBL-620 50 lbs.

ECLIPSE 100 $595



The Eclipse 100 is an industrially rated IEE-696 S-100 18 slot mainframe. Equipped with a 500 watt toroid modular power supply to assure operation in the most severe enviorments. Provisions for internally mounting a 5¼ Winchester disk drive. All card positions receive proper cooling from a filtered 85 cfm fan. Constructed from 304 brushed stainless steel is suitable for medical and process control applications. Use of the highest grade materials and state of the art construction techniques has made Eclipse Data Products the industry standard for quality and versatility in computer mainframes. EDP-100 50 lbs.

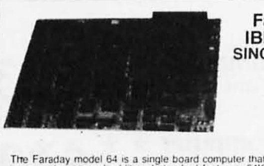
MORROW DESIGNS Micro Decision MD1

Include $1800 worth of FREE software.

$843

The Morrow Micro Decision offers one of the best values in small business computers. Standard features include 64K of RAM, 4MHz Z 80 CPU, two RS232 serial ports, dual density floppy disk controller capable of supporting four disk drives, and a 200 Kilobyte 5¼" disk drive. The Micro Decision is delivered complete with CP/M 2.2 as well as Basic 80, Wordstar and other software packages. MDS-MD1 18 lbs.

Also available pictured above, the Micro Decision MD2 with two 5¼" disk drives at only $1195.00 MDS-MD2 22 lbs.



Faraday Electronics IBM PC COMPATIBLE SINGLE BORAD COMPUTER $479

The Faraday model 64 is a single board computer that is compatable with the I.B.M PC, plus incorporates several additional standard features. 64K of RAM memory expandible to 256K. Centronics printer port and two RS-232 serial ports are also included. 5 expansion slots are included (upgradable to 9 slots).

Other useful features include IBM compatible keyboard interface, 8087 socket, upto 32K of EPROM, 3 user available DMA channels, and 2 counter/timers. MS-DOS and CP/M 86 compatible. Board measures 8½" by 12". Requires 5 volts and + 12 volts. FAR-64

U.S. ROBOTICS 1200 BAUD MODEM $419

The U.S. Robotics 212A/103 modem represents a major advance in 1200/300 baud modem technology. Proprietary 1200 baud LSI integrated circuits allows the U.S. Robotics 212A modem to maintain higher reliability over marginal phone lines.

The U.S. Robotics 212A features auto dial, auto answer, command repeat and auto intelligent baud selection. USR-212A $419.00 2 lbs.

Other excellent values in direct connect modems: Signalman Mark 1 at $74.95 and the Universal Data 1200 baud at only 369.00

PRINTERS

$269 Star Gemini

MATRIX PRINTERS

Star Gemini-10 friction & tractor 100 char/sec. parallel	STR-G10	269.00
Star Gemini-15, 100 char./sec. 15" paper.	STR-G15	559.00
Star Coex 80FT friction & tractor	VST-C80FT	249.00
Okidata 82A serial & parallel 9½" paper	OKI-82A	419.00
Okidata 92A serial & par'l 160 char/sec	OKI-92A	495.00
Okidata 83A & parallel 15" paper	OKI-83A	595.00
Okidata 84A & parallel 15" paper	OKI-84A	629.00
Okidata 2350 (new) 350 char/sec	OKI-2350	1995.00
Epson FX80 160 char./sec. with graphtrax, fric. & tractor	EPS-FX80	575.00
Epson MX100 with graphtrax, 15" paper	EPS-MX100	695.00
NEC8023A parallel 9½" paper, graphics	NEC-8023A	395.00
Anadex 9500A high speed 15" paper	ADX-9500A	1279.00
Anadex 9501A high speed with graphics	ADX-9501A	1279.00
Datasouth 180 high speed 180 cps 15"	DSI-180	1295.00
Quantex 7030 corespondence quality 180 char/sec.	QTX-7030	1595.00
Prowriter 8510 parallel 9½" paper	PRO-8510P	495.00
Prowriter 8510 serial 9½ paper	PRO-8510S	639.00
Prowriter II, parallel 15" paper, graphics	PRO-2P	750.00
Printronix P300 high speed printer 300 lines per minute	PTX-P300	4500.00
Printronix P600 ultra high speed 600 lines per minute	PTX-P600	6150.00
Mannesmann Tally 1805 200 char/sec serial	MAN-1805	1650.00

WORD PROCESSING PRINTERS

NEC7710 55 char/second, serial interface	NEC-7710	2279.00
NEC7730 55 char/sec. par'l interface.	NEC-7730	2279.00
Silver Reed EXP500, 14 char/sec. par'l interface	SRD-EXP500	595.00
Silver Reed EXP550 17 Char/sec par'l interface	SRD-EXP550	759.00
Diablo 630 40 char/sec. serial	DBL-630	2250.00
Diablo 620, proportional spacing, horz & vert. tab. 20 cps.	DBL-620	879.00
Brother HR1A daisy wheel, parallelinterfacing	BTH-HR1P	779.00
Brother HR1A serial interface	BTH-HR1S	839.00
Starwriter F10 serial, 40 char/sec	PRO-F10S	1475.00
Starwriter F10 parallel, 40 char/sec.	PRO-F10P	1475.00

EPSON MX80 RIBBONS $6.95

MONITORS

BMC 12A green phosphor 15 MHz. composit video.	BMC-12A	88.00
BMC 12" high resolution, 20MHz	BMC-12EN	139.00
Zenith ZVM121 green phosphor 12" 40/80 column switch.	ZTH-Z121	109.00
NEC JB1201 green phosphor 18 MHz. composit video.	NEC-JB1201	169.00
NEC JB1260 commercial grade composit.	NEC-JB1260	129.00
USI Amber screen 12" composit monitor.	USI-12A	169.00
Motorola 23" open frame blk/white composit video	MOT-BW23	159.00
Motorola 12" open frame requires horz sync. and power.	MOT-BW12	69.00
Conrac 9" open frame requires horz sync. & 12v. supply.	CON-BW9	59.00
COLOR		
BMC AU9191U Color composit video with sound	BMC-9191	279.00
BMC 9191M RGB designed for use with the IBM computer.	BMC-9191M	499.00
NEC JC1203DM, RGB color monitor	NEC-1203	699.00
NEC JC1201 color composit.	NEC-JC1201	339.00
Zenith ZVM134 RGB color suitable for IBM PC	ZTH-Z134	595.00
Comrex color composit with sound	COM-6500	329.00
Amdek Color 1, composit video	AMK-100	329.00

MODEMS

DIRECT CONNECT $75.00

Hayes Smart Modem 1200 baud, auto answer, auto dial	HYS-212AD	515.00
Hayes Smartmodem, 300 baud only, auto answer, auto dial	HYS-103AD	229.00
Hayes Micromodem II, 103 Apple direct connect	HYS-MM2	279.00
Hayes Micromodem 100, S-100 auto answer, auto dial.	HYS-100	319.00
Hayes Chronograph, time & date	HYS-CHR232	199.00
U.S. Robotics 212A 300/1200 baud, auto dial/answer.	USR-212A	419.00
Penril 300/1200 auto dial,autolog	PEN-12AD	695.00
Universal Data 103LP, line power, answer & originate	UDS-103LP	169.00
Universal Data 103LPJ, Auto answer	UDS-103LPJ	219.00
Universal Data 202, 1200 baud, half duplex only	UDS-202LP	219.00
Universal Data 212LP, full 1200 baud duplex, line power	UDS-212LP	359.00
Novation 'J' Cat, direct connect, auto answer	NOV-JCAT	109.00
Novation Cat, acoustic connect	NOV-CAT	159.00
Novation SmartCat 103, auto answer, auto dial	NOV-SC103	219.00
Novation SmartCat 103/212, 1200 baud auto dial	NOV-SC212	529.00
Signalman Mark 1, direct connect with terminal cable.	SGL-MK1	75.00

TERMINALS

The Wyse 100 features die cast aluminum case, 102 key keyboard and non-glare 26 line green phosphor video display. Split screen both horizontal an vertical makes the WY-100 unusally user friendly. This unique terminal is perfect to enhance any business system.

$795

Freedom 50, split screen, detatchable keyboard	LIB-F50	475.00
Visual 50, detatchable, keyboard selectable settings.	VSL-50	659.00
Visual 50 Green screen	VSL-50G	679.00
Visual 330, emulates DEC, DG, LSI. green	VSL-330G	995.00
Ampex Dialogue 125 green screen, two page, func. keys	APX-D125G	695.00
Ampex Dialouge 125 amber screen, two page, func. keys	APX-D125A	685.00
Wyse 100, horz & vert. split screen, metal enclosure	WYS-100	795.00
Wyse 300, Eight color display, split screen.	WYS-300	1159.00
Televideo 910 Plus, block mode	TVI-910P	595.00
Televideo 925, detatchable keyboard, 22 function keys	TVI-925	795.00
Televideo 950, graphic char.,split screen, 22 func.	TVI-950	985.00
Televideo 970, 14" green screen, 132 column, European	TVI-970	1259.00
Zenith 29 terminal, VT52 compatible, detatchable keyboard	ZTH-Z29	765.00
ADDS Viewpoint A1 detatchable keyboard	ADD-VP1	585.00
ADDS Viewpoint A2, xy cursor	ADD-VP2	615.00

Microswitch ASCII KEYBOARD $79

This Honeywell Microswitch keyboard has been recently purchased from the terminal division of Lear Seigler. Each keyboard contains 81 high reliability Hall Effect keys. Outputs seven bit parallel ASCII along with strobe. Ideal for word processing applications. Complete with documentation and schematics. MIC-81SD5 3 lbs.

SOFTWARE

C P / M SOFTWARE

AdaSoft CP/M	ADA-445C	395.00
D-Base II	ASH-015C	429.00
Wordstar	MPR-187C	239.00
Mailmerge	MPR-392C	125.00
Supersoft	MPR-309C	149.00
MAC	DGR-401C	85.00
CP/M 3.0	DGR-410C	249.00
Despool	DGR-367C	45.00
Pascal Plus	DGR-004C	429.00
CP/M 86	DGR-186C	239.00
MP/M II	DGR-208C	379.00

CP/M Formats Available

8" 3740 IBM ● 8" CP/M 86
Northstar 10 Sector ● Osborne
Altos ● Heath / Zeinth 10 sector
Televideo ● Xerox ● Atari
Apple DOS ● IBM/PC ● Eagle
Cromemco ● Commodore 64

I B M BUSINESS SOFTWARE

1-2-3	LTS-009B	449.00
Superiter	SRM-002B	249.00
Super Spelgard	SRM-001B	139.00
Crosstalk	MCS-120B	139.00
D-Base II	ASH-120B	429.00
Home Accountant Plus	CNT-921B	105.00
Wordstar	MPR-123B	239.00
Mailmerge	MPR-345B	139.00
Spellstar	MPR-429B	174.00
Visicalc 2	PSW-018B	184.00
Deskplan	PSW-010B	189.00
CP/M 86	DGR-120B	239.00
Pascal 86	DGR-004B	339.00
C Basic 86	DGR-002B	725.00

APPLE BUSINESS SOFTWARE

Home Accountant Plus	CNT-915A	49.00
Visicalc 2	PSW-017A	184.95
Visifile	PSW-018A	184.95
Visitrend	PSW-014A	229.95
DeskPlan	PSW-010A	184.95
Visidex	PSW-015A	184.95
Visisched	PSW-023A	228.00
Visiterm	PSW-016A	79.95
Basic Compiler	MSF-857AC	295.00
Fortran 80	MSF-021AC	349.00
Cobol 80	MSF-546AC	529.00
Multiplan	MSF-186AC	179.00
Z80 Forth	SST-616AC	129.00
Supercalc	SRM-001AC	205.00
Mailmate	CPW-105AC	69.00
D-Base II	ASH-116AC	429.00

I B M GAMES

Air Traffic Controller	AGC-207B	23.50
Federation	AGC-601B	23.50
Lazermaze	AGC-258B	23.50
Terran Jepardy	AGC-622B	23.50
Andromenda Conquest	AVA-567B	18.15
Draw Poker	AVA-342B	16.50
Galaxy	AVA-975B	19.50
Midway Campaign	AVA-758B	16.95
Voyager I	AVA-867B	19.50
Apple Panic	BRB-636B	23.50
Curse of Ra	EPX-866B	19.95
Jabbertalky	EPX-156B	23.50
Oil Baron's	EPX-214B	78.50
Temple of Apshai	EPX-109B	31.95
Deadline	INF-893B	35.00
Starcross	INF-514B	28.00
Zork I,II or III	INF-757B	28.00
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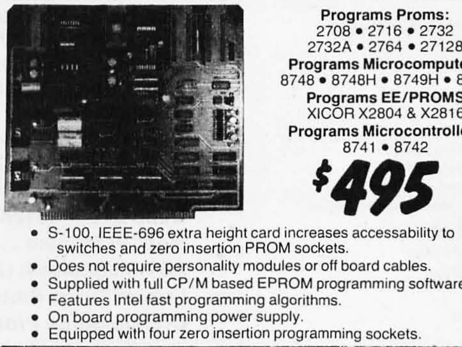

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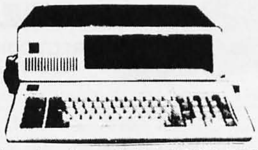

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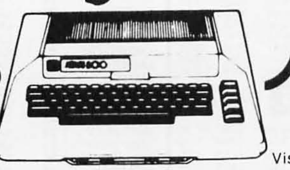

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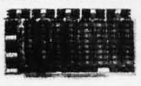

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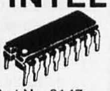

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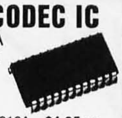

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19 Column Printer prints 16 numerical columns plus 3 columns which have math, alpha and other notations. Each wheel has 12 positions with position 12 blank. Position 11 on numerical columns have decimal point or #. Utilizes 2.75" wide adding machine tape and a dual color ink ribbon. Input data parallel with four bit BCD comparator circuit. Print rate, 3 lines per second. Operating voltage 22-28VDC with typical cycle time of 340mS. Size 6½"W x 3⅛"H x 5⅜"Dp. New. $8.95 ea. 3/$25

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8214	4.95	6821	6.50	6530-X	24.95
8216	2.75	6828	10.50	6532	17.95
8224	2.95	6834	16.95	6551	19.95
8226	2.95	6845	22.95	Z80-PIO	6.50
8228	3.95	6847	27.95	Z80A-PIO	9.50
8243	9.50	6850	5.25	Z80-CTC	6.50
8250	14.95	6852	5.25	Z80A-CTC	9.50
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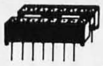

LOW PROFILE SOCKETS (TIN)

	1-24	25-49	50-100
8 pin LP	.16	.15	.14
14 pin LP	.20	.19	.18
16 pin LP	.22	.21	.20
18 pin LP	.29	.28	.27
20 pin LP	.34	.32	.30
22 pin LP	.29	.27	.24
24 pin LP	.38	.37	.36
28 pin LP	.45	.44	.43
40 pin LP	.60	.59	.58

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10 pin WW (Tin)	.65	.63	.58
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16 pin WW	.80	.77	.70
18 pin WW	.95	.90	.81
20 pin WW	1.15	1.08	.99
22 pin WW	1.45	1.35	1.23
24 pin WW	1.35	1.26	1.14
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LM339N	.95	CA3080T	1.29
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LM360N	1.49	CA3130T	1.30
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LM733N/H	.98	SN75451N	.35
LM739N	1.15	SN75452N	.49
LM741CN/H	.33	SN75453N	.49
LM741CN-14	.19	SN75454N	.49
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74S05	.52	74S136	1.69	74S258	1.29
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74S15	.42	74S153	1.29	74S373	3.10
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74S30	.42	74S160	2.79	74S471	7.95
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74S38	1.19	74S175	1.49	74S473	7.95
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74S65	.46	74S196	1.89	74S571	5.75
74S74	.69	74S240	2.75	74S572	8.95
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74S113	.72	74S243	2.99	74S941	2.90
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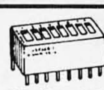

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7403	.22	7480	.49	74164	.87
7404	.22	7482	.95	74165	.87
7405	.23	7483	.55	74166	1.20
7406	.35	7485	.65	74167	1.95
7407	.35	7486	.35	74170	1.69
7408	.26	7489	1.75	74172	4.75
7409	.23	7490	.39	74173	.79
7410	.22	7491	.57	74174	.89
7411	.29	7492	.45	74175	.85
7412	.29	7493	.45	74176	.75
7413	.39	7494	.69	74177	.75
7414	.59	7495	.65	74179	1.34
7416	.29	7496	.69	74180	.75
7417	.29	7497	2.90	74181	1.75
7420	.22	74100	2.90	74182	.75
7421	.35	74107	.32	74184	2.25
7422	.29	74109	.37	74185	2.25
7423	.29	74116	1.95	74186	9.95
7425	.29	74121	.29	74188	3.90
7426	.29	74122	.39	74190	1.15
7427	.25	74123	.59	74191	1.15
7429	.45	74125	.39	74192	.85
7430	.23	74126	.44	74193	.85
7432	.29	74128	.59	74194	.85
7437	.25	74132	.69	74195	.68
7438	.29	74136	.75	74196	.85
7439	.29	74139	.95	74197	.85
7440	.19	74141	.79	74198	1.39
7441	.79	74142	2.95	74199	1.39
7442	.57	74143	2.95	74221	1.19
7443	.95	74144	2.95	74251	.95
7444	.95	74145	.62	74273	1.05
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7446	.79	74148	1.20	74279	.75
7447	.65	74150	1.09	74283	1.40
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7450	.19	74152	.67	74285	3.90
7451	.19	74153	.67	74290	1.25
7453	.19	74154	1.19	74298	.95
7454	.19	74155	.78	74365	.68
7459	.25	74156	.78	74366	.68
7460	.23	74157	.69	74367	.68
7470	.29	74158	1.65	74368	.68
7472	.29	74159	2.49	74390	1.45
7473	.34	74160	.88	74393	1.90
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74LS03	.28	74LS123	1.19	74LS249	1.19
74LS04	.35	74LS124	1.35	74LS251	1.40
74LS05	.28	74LS125	.89	74LS253	1.40
74LS08	.28	74LS126	.52	74LS257	.85
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74LS10	.28	74LS136	.49	74LS259	2.95
74LS11	.39	74LS138	.85	74LS260	.65
74LS12	.33	74LS139	.85	74LS261	2.49
74LS13	.47	74LS145	1.25	74LS266	.59
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74LS20	.26	74LS153	.79	74LS279	.59
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74LS27	.33	74LS157	.85	74LS295	1.10
74LS28	.33	74LS158	.75	74LS298	1.19
74LS30	.26	74LS160	1.05	74LS324	1.75
74LS32	.33	74LS161	1.15	74LS347	1.95
74LS33	.55	74LS162	1.05	74LS348	1.95
74LS37	.45	74LS163	1.05	74LS352	1.19
74LS38	.39	74LS164	1.19	74LS353	1.19
74LS40	.26	74LS165	.89	74LS363	1.49
74LS42	.79	74LS166	2.48	74LS365	.69
74LS47	.79	74LS168	1.15	74LS366	.69
74LS48	.95	74LS169	1.15	74LS367	.69
74LS51	.26	74LS170	1.99	74LS368	.69
74LS54	.29	74LS173	.89	74LS373	1.89
74LS55	.29	74LS174	.89	74LS374	1.89
74LS73	.45	74LS175	.89	74LS375	.69
74LS74	.42	74LS181	2.20	74LS377	1.95
74LS75	.59	74LS190	1.15	74LS385	1.95
74LS76	.45	74LS191	1.15	74LS386	.65
74LS78	.45	74LS192	.98	74LS390	1.95
74LS83A	.79	74LS193	.98	74LS393	1.95
74LS85	1.19	74LS194	1.15	74LS395	1.70
74LS86	.45	74LS195	.95	74LS399	2.35
74LS90	.57	74LS196	.89	74LS424	2.95
74LS92	.75	74LS197	.89	74LS668	1.75
74LS93	.75	74LS221	1.15	74LS670	2.29
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74LS96	.98	74LS242	1.69	81LS96	1.69
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4013	.45	4050	.69	14419	4.95
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4022	1.15	4069	.35	4511	1.19
4023	.29	4070	.49	4512	1.39
4024	.75	4071	.35	4515	2.75
4025	.25	4072	.35	4516	1.45
4027	.65	4073	.35	4518	1.39
4028	.85	4075	.35	4520	1.25
4029	1.29	4076	1.29	4555	4.95
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4031	3.25	4078	.35	4566	2.25
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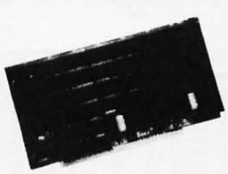

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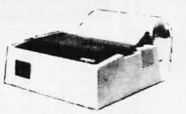

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Shugart	SA801R	$385	$379	$369	Tandon	848-1	$369	$362	$353
Siemens	FDD100-8	199	199	Call					
DOUBLE-SIDED 8"									
Shugart	SA851R	519	495	469	Siemens	FDD200-8	399	389	379
Qume	Datatrack 8	515	490	465	Tandon	848-2	479	475	469
Shugart	860 Thin	559	539	519					
SINGLE-SIDED 5¼"									
Shugart	SA400	210	208	198	Tandon	TM100-1	205	198	195
MPI	B51	210	208	198	Pertec	FD200	149	149	139
DOUBLE-SIDED 5¼"									
Shugart	SA450	345	325	313	Tandon	TM100-2	289	265	259
Pertec	FD250	159	159	149					
DOUBLE-SIDED 5¼" Thinline									
TEAC	5¼" Thinline	375	365	359	Qume	5¼" Thinline	375	365	359
DOUBLE-SIDED 3"									
Hitachi		Call	Call	Call					
WINCHESTERS 5¼"									
Seagate	ST506(6Mb)	699	679	599	Seagate	ST512(12Mb)	990	975	949
IMI	5006(6Mb)	865	850	819	IMI	5012(12Mb)	1088	1070	1020
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P/N MG-256SP add'l Ser, Par	1095	749
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P/N I/O-SP, Clk, (2) Ser, Par	265	199
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COEX		
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CORVUS Hard Disk System		Call
DAVONG		
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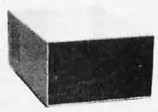

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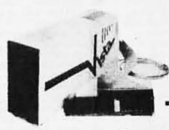

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SN7402N	14	.25
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SN7404N	14	.25
SN7405N	14	.25
SN7406N	14	.29
SN7407N	14	.29
SN7408N	14	.25
SN7409N	14	.25
SN7410N	14	.25
SN7411N	14	.25
SN7412N	14	.35
SN7413N	14	.35
SN7414N	14	.49
SN7416N	14	.25
SN7417N	14	.25
SN7420N	14	.19
SN7421N	14	.35
SN7422N	14	.45
SN7423N	16	.59
SN7425N	14	.29
SN7426N	14	.29
SN7427N	14	.25
SN7428N	14	.49
SN7430N	14	.25
SN7432N	14	.29
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SN7438N	14	.29
SN7439N	14	.59
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SN7441N	16	.89
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SN7450N	14	.19
SN7451N	14	.19
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SN7460N	14	.19
SN7470N	14	.29
SN7472N	14	.29
SN7473N	14	.35
SN7474N	14	.35
SN7475N	16	.45
SN7476N	16	.35
SN7479N	14	4.95
SN7480N	14	.69
SN7482N	14	1.19
SN7483N	16	.59
SN7485N	16	.59
SN7486N	14	.35
SN7489N	16	2.25
SN7490N	14	.39
SN7491N	14	.59
SN7492N	14	.39
SN7493N	14	.39
SN7494N	14	.69
SN7495N	14	.49
SN7496N	16	.49
SN7497N	16	2.75
SN74100N	24	1.49
SN74104N	14	.89
SN74105N	14	.89
SN74107N	**14**	**.29**
SN74109N	**16**	**.39**
SN74116N	24	1.49
SN74121N	14	.39
SN74122N	14	.55
SN74123N	16	.49
SN74125N	14	.45
SN74126N	14	.45
SN74132N	14	.49
SN74136N	14	.69
SN74141N	16	.69
SN74142N	16	2.95
SN74143N	24	2.95
SN74144N	24	2.95
SN74145N	16	.59
SN74147N	16	1.49
SN74148N	16	1.19
SN74150N	24	1.19
SN74151N	16	.59
SN74152N	14	.59
SN74153N	16	.59
SN74154N	24	1.25
SN74155N	16	.59
SN74156N	16	.59
SN74157N	**16**	**.59**
SN74160N	16	.69
SN74161N	16	.69
SN74162N	16	.69
SN74163N	16	.69
SN74164N	14	.69
SN74165N	16	.69
SN74166N	16	.89
SN74167N	16	2.79
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SN74174N	16	.69
SN74175N	16	.69
SN74176N	14	.69
SN74177N	14	.69
SN74179N	16	1.49
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SN74190N	16	.69
SN74191N	16	.69
SN74192N	16	.69
SN74193N	16	.69
SN74194N	16	.69
SN74195N	16	.69
SN74196N	14	.89
SN74197N	14	.89
SN74198N	24	1.19
SN74199N	24	1.19
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SN74284N	16	2.95
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SN74368N	16	.55
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74LS

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74LS01	14	.25
74LS02	14	.25
74LS03	14	.25
74LS04	14	.29
74LS05	14	.29
74LS08	14	.29
74LS09	14	.29
74LS10	14	.29
74LS11	14	.35
74LS12	14	.35
74LS13	14	.39
74LS14	14	.59
74LS15	14	.35
74LS20	14	.29
74LS21	14	.29
74LS22	**14**	**.29**
74LS26	14	.29
74LS27	14	.29
74LS28	14	.35
74LS30	14	.29
74LS32	14	.35
74LS33	14	.55
74LS37	14	.35
74LS38	14	.35
74LS40	14	.29
74LS42	16	.55
74LS47	16	.75
74LS48	16	.75
74LS49	14	.75
74LS51	14	.25
74LS54	14	.25
74LS55	14	.29
74LS73	14	.39
74LS74	14	.39
74LS75	16	.39
74LS76	16	.39
74LS78	14	.39
74LS83	16	.65
74LS85	16	.69
74LS86	14	.39
74LS90	14	.55
74LS92	14	.55
74LS93	14	.55
74LS95	14	.79
74LS96	16	.89
74LS107	14	.39
74LS109	16	.39
74LS112	16	.39
74LS113	14	.39
74LS114	14	.39
74LS122	14	.49
74LS123	16	.79
74LS125	14	.49
74LS126	14	.49
74LS132	14	.59
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74LS161	16	.69
74LS162	16	.69
74LS163	16	.69
74LS164	14	.69
74LS165	16	1.19
74LS168	16	1.19
74LS169	16	1.19
74LS170	16	1.49
74LS173	16	.69
74LS174	16	.59
74LS175	16	.59
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74LS191	16	.89
74LS192	16	.79
74LS193	16	.79
74LS194	16	.69
74LS195	16	.69
74LS197	14	.79
74LS221	16	.89
74LS240	20	1.09
74LS241	20	1.09
74LS242	14	1.09
74LS243	14	1.09
74LS244	20	1.09
74LS245	20	1.49
74LS247	16	1.09
74LS248	16	1.09
74LS249	16	1.09
74LS251	16	.59
74LS253	16	.59
74LS257	16	.59
74LS258	16	.59
74LS260	14	.59
74LS266	14	.69
74LS273	20	1.49
74LS279	16	.49
74LS283	16	.69
74LS290	14	.89
74LS293	14	.79
74LS298	16	.89
74LS352	16	1.29
74LS353	16	1.29
74LS365	16	.49
74LS366	16	.49
74LS367	16	.49
74LS368	16	.49
74LS373	20	1.29
74LS374	20	1.29
74LS375	16	.69
74LS386	14	.45
74LS393	14	1.19
74LS399	16	1.49
74LS670	16	1.49
81LS95	20	1.49
81LS97	20	1.49

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74S00	14	.35
74S02	14	.35
74S03	14	.35
74S04	14	.45
74S05	14	.45
74S08	14	.39
74S09	14	.39
74S10	14	.35
74S11	14	.35
74S15	14	.35
74S20	14	.35
74S22	14	.35
74S30	14	.35
74S32	14	.45
74S38	14	.89
74S40	14	.39
74S51	14	.35
74S64	14	.39
74S65	14	.39
74S74	14	.55
74S86	14	.55
74S112	16	.55
74S113	14	.55
74S114	14	.55
74S124	16	2.95
74S133	16	.45
74S134	16	.50
74S135	16	.69
74S136	14	1.39
74S138	16	.89
74S139	16	.89
74S140	14	.55
74S151	16	.99
74S153	16	.99
74S157	16	.99
74S158	16	.99
74S160	16	2.49
74S174	16	.99
74S175	16	.99
74S188*	16	1.49
74S194	16	1.49
74S195	16	1.49
74S196	14	1.49
74S240	20	2.25
74S241	20	2.25
74S242	14	2.49
74S243	14	2.49
74S244	20	2.49
74S251	16	1.19
74S253	16	1.19
74S257	16	1.19
74S258	16	1.19
74S260	14	.79
74S280	14	1.95
74S287*	16	1.95
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74S373	20	2.49
74S374	20	2.49
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74S475*	24	4.95
74S570*	16	2.95
74S571*	16	2.95
74S572*	18	4.95
74S573*	18	4.95
74S940	20	2.49
74S941	20	2.49

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CA3013H		2.15
CA3023H		3.25
CA3035H		5.95
CA3039H		1.35
CA3046N	14	.89
CA3059N	14	3.25
CA3060N	16	3.25
CA3080E	8	.89
CA3081N	16	1.49
CA3082N	16	1.49
CA3083N	16	1.49
CA3086N	14	.69
CA3089N	16	1.69
CA3096N	16	1.19
CA3130E	8	1.49
CA3140E	8	.99
CA3160H		1.95
CA3401N	14	.59
CA3600N	14	3.95

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Part No.	**Pins	Price
CD4000	14	.29
CD4001	**14**	**.29**
CD4002	14	.29
CD4006	14	.89
CD4007	14	.29
CD4009	**16**	**.39**
CD4010	16	.39
CD4011	14	.29
CD4012	**14**	**.15**
CD4013	14	.39
CD4014	16	.79
CD4015	**16**	**.39**
CD4016	14	.39
CD4017	16	.75
CD4018	16	.79
CD4019	16	.39
CD4020	16	.75
CD4021	16	.79
CD4022	16	.79
CD4023	14	.29
CD4024	14	.69
CD4025	14	.23
CD4026	16	2.49
CD4027	16	.45
CD4028	16	.69
CD4029	16	.79
CD4030	14	.29
CD4034	24	1.95
CD4035	16	.89
CD4040	16	.79
CD4041	14	.79
CD4042	16	.69
CD4043	16	.79
CD4044	16	.79
CD4046	16	.89
CD4047	14	.89
CD4048	16	.39
CD4049	**16**	**.39**
CD4050	16	.39
CD4051	16	.79
CD4052	16	.79
CD4053	16	.79
CD4056	16	2.95
CD4059	24	7.95
CD4060	16	.89
CD4066	14	.39
CD4068	14	.39
CD4069	14	.29
CD4070	14	.39
CD4071	14	.29
CD4072	14	.29
CD4073	14	.29
CD4075	14	.29
CD4076	16	.79
CD4078	14	.29
CD4081	**14**	**.29**
CD4093	14	.49
CD4098	16	1.95
CD4506	16	1.19
CD4507	14	.39
CD4508	24	3.95
CD4510	16	.89
CD4511	16	.89
CD4512	16	.89
CD4514	24	1.79
CD4515	24	1.79
CD4516	16	.99
CD4518	16	.99
CD4519	16	.39
CD4520	16	.79
CD4526	16	1.19
CD4528	16	1.19
CD4529	16	1.19
CD4543	16	1.19
CD4562	14	6.95
CD4566	16	1.39
CD4583	16	2.49
CD4584	14	.59
CD4723	16	1.19
CD4724	16	1.19
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MC14410	16	13.95
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MC14412	16	13.95
MC14419	16	7.95
MC14433	24	13.95
MC14538	16	1.19
MC14541	14	1.19

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Z80A-DMA	40	Direct Memory Access Circuit	17.95
Z80A-P10	40	Parallel I/O Interface Controller	5.95
Z80A-S10/0	40	Serial I/O (TxCB and RxCB bonded)	16.95
Z80A-S10/1	40	Serial I/O (Lacks DTRB)	16.95
Z80A-S10/2	40	Serial I/O (Lacks SYNCB)	16.95
Z80A-S10/9	40	Serial I/O	16.95
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MC6821	40	Peripheral Inter. Adapt (MC6820)	4.95
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MC6850	24	Asynchronous Comm. Adapter	4.95
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DP8275	40	Prog. CRT Controller	29.95
DP8279	40	Prog. Keyboard/Display Interface	8.95
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DP8307	20	8-bit Bi-Directional Receiver	2.49
DP8308	20	8-bit Bi-Directional Receiver	2.49
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DP8311	20	Octal Latched Peripheral Driver	4.95

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M-CDP1802	User Manual	7.50
M-2650	User Manual	5.00
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30003	1982 Nat. Linear Book (1952 pg.)	11.95
30008	1980 Nat. Memory Data Book (464 pg.)	6.95
30011	1980 Nat. Linear Applications (736 pg.)	15.95
30013	1983 Zilog Data Book (641 pg.)	7.95

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DS0026CN	8	Dual MOS Clock Driver (5MZ)	1.95
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MM5369EST	8	Prog. Oscillator/Divider (100Hz)	1.19

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4116N-3	16	16,384x1	(200ns)	1.69 - 8/12.95
4116N-4	16	16,384x1	(250ns)	1.49 - 8/10.95
4164N-150	16	65,536x1	(150ns)	7.95 - 8/59.95
4164N-200	16	65,536x1	(200ns)	7.49 - 8/54.95
MM5261	18	1024x1	(300ns)	.49 - 8/1.95
MM5262	**22**	**2048x1**	**(365ns)**	**.49 — 8/1.95**
MM5270	18	4096x1	(250ns) MK4096	4.95
MM5280	22	4096x1	(200ns) 2107	3.95
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MM5290-3	16	16,384x1	(200ns)	1.69 - 8/12.95
MM5290-4	16	16,384x1	(250ns)	1.49 - 8/10.95
MM5298-3	16	8192x1	(200ns)	1.69

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HM6116-4	24	2048x8	(200ns) CMOS	6.95
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74S206	16	256x1	(60ns) 93411	3.95
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82S10	16	1024x1	(50ns) O.C. (93415)	3.95
82S25	16	16x4	(50ns) O.C. (74S289)	2.25

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Part No.	**Pins			Price
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2708	24	1024x8	(450ns)	3.95
2708-5	24	1024x8	(550ns) SM00246	2.95
TMS2516	24	2048x8	(450ns) 2716	6.95
TMS2532	24	4096x8	(450ns) NMC2532	9.95
TMS2564	28	8192x8	(450ns)	19.95
TMS2716	24	2048x8	(450ns) 3 voltage	7.95
2716	24	2048x8	(450ns)	4.95
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2732	24	4096x8	(450ns)	9.95
2758Q	24	1024x8	(450ns) single +5V	2.95
MM2764	28	8192x8	(450ns)	16.95
MM2764-3	28	8192x8	(300ns)	19.95
MCM68764	24	8192x8	(450ns)	39.95
74S188	16	32x8	PROM O.C. (6330-1)	1.49
74S287	16	256x4	PROM T.S. (6301-1)	1.95
74S288	16	32x8	PROM T.S. (6331-1)	1.95
74S387	16	256x4	PROM O.C. (6300-1)	1.95
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74S472	20	512x8	PROM T.S. (6349-1)	4.95
74S473	20	512x8	PROM O.C. (6348)	4.95
74S474	24	512x8	PROM T.S. (DM87S296N)	4.95
74S475	24	512x8	PROM O.C. (6340)	4.95
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74S571	16	512x4	PROM T.S. (6306)	2.95
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74S573	18	1024x4	PROM T.S. (82S137)	4.95
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82S123	16	32x8	PROM T.S. (27S19)	2.95
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82S129	16	256x4	PROM T.S. (27S21)	3.95
82S130	16	512x4	PROM O.C. (27S12)	5.95
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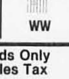
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INTERSIL

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7226AEV/Kit*	40	5 Function Counter Chip, XTL	74.95

30009 1983 INTERSIL Data Book (1356p.) **.... $9.95**

NEW PRODUCT! 74HC High Speed CMOS

Part No.	**Pins	Price
74HC00	14	.75
74HC02	14	.75
74HC03	14	.75
74HC04	14	.69
74HCU04	14	.75
74HC08	14	.75
74HC10	14	.75
74HC11	14	.69
74HC14	14	.85
74HC20	14	.75
74HC27	14	.75
74HC32	14	.75
74HC42	16	1.39
74HC73	14	.75
74HC74	14	.99
74HC75	16	.99
74HC76	16	.75
74HC85	16	2.19
74HC86	14	.99
74HC107	14	.75
74HC109	16	1.39
74HC112	16	.75
74HC113	14	.75
74HC132	14	.89
74HC138	16	1.49
74HC139	16	1.49
74HC147	16	1.19
74HC151	16	1.19
74HC153	16	.99
74HC157	16	1.19
74HC158	16	1.59
74HC160	16	1.79
74HC161	16	1.79
74HC164	14	1.79
74HC165	16	2.39
74HC173	16	1.59
74HC174	16	1.39
74HC175	16	1.39
74HC192	16	1.39
74HC193	16	1.39
74HC194	16	1.59
74HC195	16	1.49
74HC242	14	2.79
74HC243	14	2.79
74HC251	16	1.19
74HC253	16	.99
74HC257	16	1.19
74HC259	16	1.49
74HC266	14	.99
74HC280	14	4.95
74HC373	20	3.95
74HC374	20	3.95
74HC390	16	1.49
74HC393	14	1.49
74HC533	20	3.95
74HC534	20	3.95
74HC595		3.75
74HC688		3.19
74HC4002	14	.79
74HC4020	16	2.19
74HC4024	14	1.59
74HC4040	16	2.19
74HC4060	16	2.19
74HC4075	14	.75
74HC4078	14	.69
74HC4511	16	3.29
74HC4514	24	4.79
74HC4538	16	2.95
74HC4543	16	4.95

74HCU04 is unbuffered. All others are buffered. **Send $.30 for Data Sheet.**

NEW Programmable Array Logic (PALS)

Part No.	**Pins	Function	Price
PAL10H8	20	Octal 10-Input AND-OR Gate Array (High Output)	$5.95
PAL12H6	20	Hex 12-Input AND-OR Gate Array (High Output)	5.95
PAL14H4	20	Quad 14-Input AND-OR Gate Array (High Output)	5.95
PAL10L8	20	Octal 10-Input AND-OR-Invert Gate Array (Low Output)	5.95
PAL12L6	20	Hex 12-Input AND-OR-Invert Gate Array (Low Output)	5.95
PAL14L4	20	Quad 14-Input AND-OR-Invert Gate Array (Low Output)	5.95
PAL16L8	20	Octal 16-Input AND-OR-Invert Gate Array (Low Output)	9.95
PAL16R8	20	Octal 16-Input Register AND-OR Gate Array	9.95
PAL16R6	20	Hex 16-Input Register AND-OR Gate Array	9.95
PAL16R4	20	Quad 16-Input Register AND-OR Gate Array	9.95

30012 1982 NATIONAL PAL Data Book (176p.) **.. $5.95**

74C—C/MOS

Part No.	**Pins	Price
74C00	14	.35
74C02	14	.35
74C04	14	.29
74C08	14	.35
74C10	14	.35
74C14	14	.59
74C20	14	.35
74C30	14	.35
74C32	14	.39
74C42	16	1.39
74C48	16	1.95
74C73	14	.79
74C74	14	.69
74C85	16	1.95
74C86	14	.39
74C89	16	5.95
74C90	14	1.19
74C93	14	1.19
74C95	14	1.39
74C107	14	.89
74C151	16	2.49
74C154	24	3.49
74C157	16	2.25
74C160	16	1.19
74C161	16	1.19
74C162	16	1.19
74C163	16	1.19
74C164	14	1.49
74C173	16	.79
74C174	16	1.19
74C175	16	1.19
74C192	16	1.49
74C193	16	1.69
74C195	16	1.39
74C221	16	1.95
74C240	20	1.95
74C244	20	1.95
74C373	20	2.49
74C374	20	2.49
74C901	14	.59
74C903	14	.59
74C906	14	.59
74C911	28	8.95
74C912	28	8.95
74C915	18	1.19
74C917	28	8.95
74C922	18	4.49
74C923	20	4.95
74C925	16	5.95
74C926	18	5.95
80C95	16	.39
80C97	16	.39

LINEAR

Part No.	**Pins	Price
TL071CP	8	.79
TL072CP	8	1.39
TL074CN	14	1.95
TL081CP	8	.59
TL082CP	8	1.19
TL084CN	14	1.95
LM301CN	8	.35
LM302H		1.95
LM304H		1.95
LM305H		.99
LM307CN	8	.45
LM308CN	8	.69
LM309K		1.25
LM310CN	8	1.75
LM311CN	8	.69
LM312H		2.49
LM317T		1.19
LM317K		3.95
LM318CN	8	1.95
LM319N	14	1.95
LM320K-5		1.35
LM320K-12		1.35
LM320K-15		1.35
LM320T-5		.89
LM320T-12		.89
LM320T-15		.89
LM323K		5.95
LM324N	14	.59
LM337T		1.95
LM338K		6.95
LM339N	14	.69
LM340K-5		1.35
LM340K-12		1.35
LM340K-15		1.35
LM340T-5		.79
LM340T-12		.79
LM340T-15		.79
LM348N	14	.99
LM350K		4.95
LF355N	8	1.10
LF356N	8	1.10
LM370N	14	4.49
LM373N	14	3.95
LM377N	14	1.95
LM380N	14	.89
LM381N	14	1.79
LM382N	14	1.39
LM384N	14	1.79
LM386N-3	8	.89
TL494CN	16	2.95
TL496CP	8	1.19
NE510A	14	4.95
NE529A	14	2.95
NE531V	8	2.95
NE536H		8.95
NE540H		4.95
NE544N	14	2.95
NE550A	14	1.95
NE555V	8	.35
LM556N	14	.69
NE564N	16	2.95
LM565N	14	1.19
LM566CN	8	1.49
LM567V	8	.89
NE570N	16	3.95
LM703CN	8	1.19
LM709N	14	.49
LM710N	14	.69
LM711N	14	.79
LM723N	14	.55
LM733N	14	1.00
LM739N	14	1.95
LM741CN	8	.35
LM747N	14	.69
LM748N	8	.59
LM1310N	14	1.49
LM1458CN	8	.59
LM1488N	14	.69
LM1489N	14	.69
LM1496N	14	1.95
LM1800N	16	1.49
LM1889N	18	1.95
LM1896N	14	2.95
LM2002T		1.49
LM3189N	16	1.59
LM3900N	14	.59
LM3905CN	8	1.19
LM3909N	8	.99
LM3914N	18	3.49
LM3915N	18	3.49
LM3916N	18	3.49
RC4136N	**14**	**1.25**
RC4151NB	8	1.95
NE5532	8	2.49
NE5534	8	1.69
ICL8038B	14	3.95
LM13080N	8	1.19
LM13600N	16	1.19

MORE AVAILABLE

30003 1982 Nat. Linear Data Book (1952 pgs.) **. $11.95**

Circle 219 on inquiry card.

COMPUTER-PERIPHERAL SWITCHERS

Connect any number of peripherals to a single I/O port — use a single printer to support several microcomputers — use two or more printers to support a single microcomputer — access a modem from any of several microcomputers — Ideal for demonstrating or comparing equipment. The Selecto-Switches are designed to eliminate the unnecessary plugging & unplugging of cables which connect printers, terminals, or modems to various computers. By using a Selecto-Switch, you achieve more efficient system operation, better utilization of peripherals & computer ports, eliminate redundant hardware & reduce service calls. 5 yr. limited warranty on all Selecto-Switches. No power required. Size (inches): 10L x 7W x 3H. 2½ lbs.

RS232 SERIAL SELECTO-SWITCH

• Switches all lines of asynchronous data • Easy expansion of serial ports • Connectors are female DB25 type

PART NO.	DESCRIPTION	PRICE
GRS232-AB	2-Way Switch	$139.95
GRS232-ABC	3-Way Switch	$179.95

DB25 PARALLEL SELECTO-SWITCH

• TRS-80, Apple, and IBM compatible • Switches 24 lines (line 1 is ground) • Connectors are female DB25 type

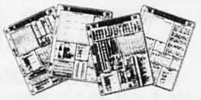
PART NO.	DESCRIPTION	PRICE
GP24-AB	2-Way Switch	$139.95
GP24-ABC	3-Way Switch	$179.95

CENTRONICS-STYLE SELECTO-SWITCH

• Switches all 36 lines • Connectors are female Centronics

PART NO.	DESCRIPTION	PRICE
GCENT-AB	2-Way Switch	$199.95
GCENT-ABC	3-Way Switch	$229.95

Micro-Logic Corp. MICRO-CHARTS



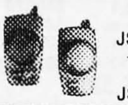
• Fully decoded data • Instant access • 2-sided, totally comprehensive • Compact 8½ x 11 in. durable credit card plastic • Perfect for programmers & engineers • Clear & concise tables for: full instruction set, disassembly, ASCII, base conversion, effect of flags, compare vs. jump, interrupt structure, pinout, cycle times, diagrams, bug notes, & much more...

PART NO.	REFERENCE	PRICE
ML-Z80	Z80 CPU	$5.95
ML-8080A	8080A/8085A	$5.95
ML-6502	6502 (65XX)	$5.95
ML-8048	8048, Relatives, Algorithms	$5.95
ML-7400	5400/7400 TTL	$5.95

BOOKS

30001	**National CMOS Data Book (1981)** (640 pages) 74C, CD4000, and A/D Converters	$6.95
30003	**National Linear Data Book (1982)** (1376 pages) LM, LF, ADC, DAC, LH Series	$11.95
30008	**National Memory Data Book (1980)** (464 pages) RAMs, ROMs, PROMs, EPROMs Series	$6.95
30009	**Intersil Data Book (1983)** (1356 pages) Complete line.	$9.95
30010	**National Audio/Radio Handbook (1980)** (240 pages) Pre-Amps, AM, FM & FM Stereo, Power Amps	$5.95
30011	**National Linear Application Handbook (1980)** (736 pages) Application Notes, Linear Briefs, etc.	$15.95
30012	**National PAL Data Book (1982)** (176 pages) Application Notes, Linear Briefs, etc.	$5.95
30013	**Zilog Data Book (1983)** (641 pages) Microprocessors and Support Chips	$7.95
210830	**Intel Memory Components Handbook (1983)** (798 pages) Contains all Application Notes, Article Reprints, Data Sheets, and other design information on Intel's RAMs, EPROMs, E²PROMs & Bubble Memories.	$14.95
210844	**Intel Microprocessor & Peripheral Handbook (1983)** (1027 pages) Contains Data Sheets on all of Intel's Micronrocessors and Peripherals.	$14.95

ATARI

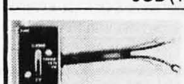


ATARI PADDLES

JSP (2) .... $4.95 pair

ATARI DRIVER

JSD(1) .... $2.95 ea.



TV GAME SWITCH

Used on Atari. Cosmetically blemished. 100% functional.

TGS-1 . . . $2.95 ea.

Jameco Digital Thermometer Kit

Dual sensors — switch controls for indoor/outdoor or dual monitoring — can be extended to 500 feet. Continuous LED .8" ht. display. Range: -40°F to 199°F, -40°C to 100°C. Accuracy ±1° nominal. Calibrate for Fahrenheit/Celsius. Simulated walnut case. AC wall adapter included. Size: 6⅝"L x 3¼"H x 1⅞"D.

JE300 . . . . . . $39.95

Universal Computer Keyboard Enclosures

"DTE" Blank Desk-Top Enclosures are designed for easy modification. High strength epoxy molded end pieces in mocha brown finish. Sliding rear/bottom panel for service/component access. Top/bott. panels .080" thick alum. alodine type 1200 finish (gold tint color) for best paint adhesion after modification. Vented top & bottom panels for cooling efficiency. Rigid construction provides unlimited applications. Assembly instructions included.

DTE-8	Panel Width 7.5"	$24.95
DTE-11	Panel Width 10.13"	$27.95
DTE-14	Panel Width 13.5"	$29.95
DTE-20	Panel Width 19.25"	$34.95

TIMEX sinclair 1000

• Powerful - fully programmable 2K memory • Portable - 6⅞" x 6⅞" x 1⅞" - 12 oz. • Expandable - Optional 16K RAM module • Single-key entry commands • Educational • Unique syntax-check report codes for error identity • Accurate to 9½ decimal places for full range math and scientific functions • Graph drawing and animated display • Advanced 4-chip design combining power, portability and affordable price.

TS1000 . . . . $54.95

ACCESSORIES FOR TIMEX sinclair 1000 and ZX81

TIMEX sinclair 1016	Expansion from 2K to 16K, size: 3" x 3" x 1.5" (5 oz)	TS1016	$49.95
TIMEX sinclair 2040	32 column thermal printer (4 lbs)	TS2040	$99.95
	Printer paper - 3 rolls (4.3 in. x 82 ft.)	TPP-3	$5.95

Keyboard Mask for Your ZX81/1000* Computer

BRAND NEW!!

JE681 KEYBOARD MASK

FEATURES:

- Install in seconds. Remove adhesive backing from mask and place over keyboard.
- All characters and symbols reproduced on mask.
- Durable — formed with polycarbonite sheet-satin finish.

The JE681 Keyboard Mask provides users of the ZX81/1000 series computer the individual feel of each keypad on the keyboard. The mask has a raised outline around each keypad allowing the user to feel and correctly position their fingers onto the keyboard.

JE681 KEYBOARD MASK . . . . . $9.95 each

Jameco ZX81/1000* Keyboard Conversion Kit

JE682-AK KEYBOARD KIT MOUNTED IN DTE-AK ENCLOSURE. LIGHT TAN PANELS WITH MOLDED DARK BROWN END PIECES. SIZE: 14¼"W x 3½"D x 3½"H

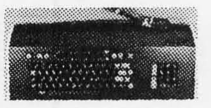
The JE682 Kit provides users of the ZX81/1000 series computers a full-size industrial keyboard hook-up to their computer. The JE682 Kit allows the use of either the full-size keyboard or the Sinclair/Timex Keyboard. The Kit also permits the simple disconnection of the Sinclair/Timex Keyboard for portable use. The JE682 Kit consists of a full-size industrial grade keyboard with 62 keys, 2 p.c. boards, 24" ribbon cable, DIP socket and 4 rubber feet. The keyboard conversion kit can easily be mounted into the DTE-AK enclosure. This enclosure is large enough to contain the ZX81/1000 computer and the full-size keyboard together. A handy label representing the ZX81/1000 keyboard layout is placed on the enclosure.

JE682-AK Keyboard Conversion Kit . . . . . . $99.95 ea.
(WITH DTE-AK CASE - AS PICTURED)

JE682 Keyboard Conversion Kit . . . . $59.95 ea.
(WITHOUT DTE-AK CASE)

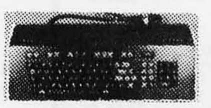
*ZX81/1000 is a trademark of Sinclair/Timex

80-Key Keyboard



CA150C $69.95

95-Key Keyboard



CA154A $79.95

CONTROL DATA KEYBOARDS

Limited Quantities!

- ★ 7-bit Parallel ASCII
- ★ SPST Switching
- ★ FTZ Shielded Base
- ★ N-Key Rollover
- ★ 128 Character ASCII
- ★ Non-Slip, Non-Glare Keycaps
- ★ CDC752 Terminal Keyboards
- ★ Attractive Case

These Control Data Keyboards consist of a base, cover, the keyboard assembly, and an interface cable. Color (case): Harvest gold and black. Color (keycaps): Black, blue, and red. Electrical requirements: +5V @ 600mA, -12V @ 50mA. Size: 21½"W × 9"D × 3½"H. Weight: 6 lbs. All units brand new in original boxes, specifications included.

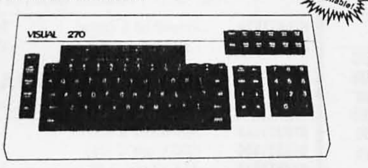
Keytronics 90-Key Soft-Programmable Keyboard

WITH SECURITY KEYLOCK SWITCH

350 Available!

BRAND NEW!!

- RFI shielded
- Cursor controls
- Numeric keyboard
- 8-bit Parallel
- Capacitance keys
- 10 user-programmable keys
- Positive TTL Logic
- Size: 17"L x 8¼"W x 2¾"H

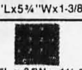


Made for Visual Technology, this keyboard features: a security keylock (includes two keys) to guard against unauthorized use; an 11-key numeric keypad; cursor controls; and 10 user-programmable keys. Electrical requirements: +5VDC. Color (case): White. Color (keycaps): Black. Complete with case, keyboard assembly, 40-inch interface cable, and schematics. Weight: 7 lbs.

Part No. KB270 . . . . $79.95 each

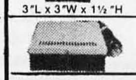
23"Lx5¾"Wx1-3/8"H

MICRO SWITCH 85-KEY KEYBOARD
Word Processing Keyboard, 26 Pin Edge Card Connection. Supply Voltage +5VDC. Main Keyboard is QWERTY. Additional Key Pads for Cursor and word processing functions.
Part No. 85SD18-1 . . . . $29.95 each



3"L x 3"W x 1½"H

HI-TEK 14-KEY NUMERIC KEYPAD
SPST switching. Charcoal grey keycaps. Mounted on printed circuit board.
Part No. K-14 . . . . $9.95 each



POWER SUPPLY +5VDC @ 1 AMP REGULATED *Transaction Tech*
Output +5VDC @ 1A (also +30VDC) reg. Input 115VAC 60Hz. 2-tone (black/beige) self-enclosed case. 6 ft., 3 cond. black power cord. 6½"W x 7"D x 2¼"H. Wt. 3 lbs. Data sheet incl.
Part No. PS51194S . . . . $14.95 each

POWER SUPPLY +5VDC @ 3 AMP REGULATED *Deltron*
Input: 115VAC, 47-440Hz. Output: 5VDC Adjustable @ 3 amp, 6VDC @ 2.5 amp. Adjustable current limit, Ripple & Noise: 1MV rms, 5MV p-p — 2 mounting surfaces. UL recognized. Size: 4"W x 4½"L x 2-7/16"H - wt. 2 lbs. Data sheet included.
Part No. QPS-1 . . . . $29.95 each

POWER SUPPLY +5VDC @ 7.5 AMP, 12VDC @ 1.5 AMP SWITCHING
Input: 115VAC, 50-60Hz @ 3 amp/230VAC, 50Hz @ 1.6 amp. Fan volt./power supply select switches (115/230VAC). Output: 5VDC @ 7.6 amp, 12VDC @ 1.6 amp. 8 ft. blk. pow. cord. 11½"W x 13¼"D x 3¾"H. Wt. 6 lbs.
Part No. PS94V0S . . . . $39.95 each

POWER SUPPLY 4-Channel Switching - Apple Compatible
FOR USE AS AN EXTERNAL POWER SUPPLY FOR APPLE
Microprocessor, mini-computer, terminal, medical equipment and process control applications. Input: 90-130VAC 47-440Hz. Output: +5VDC @ 5A, -5VDC @ 1A; +12VDC @ 1A, -12VDC @ 1A. Line reg.: ±0.2%. Ripple: 30mV p-p. Load reg.: ±1%. Overcurrent protection. Adj: 5V main output±10%. 6-3/8"L x 1-7/8"W x 4-15/16"H. Wt. 1½ lbs.
Part No. FCS-604A . . . . $69.95 each

$10.00 Minimum Order — U.S. Funds Only
California Residents Add 6½% Sales Tax
Shipping — Add 5% plus $1.50 Insurance
Send S.A.S.E. for Monthly Sales Flyer!

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2708,2716,2732 & 2764 EPROM Programmer

JE664 EPROM PROGRAMMER

8K TO 64K EPROMS — 24 AND 28 PIN PACKAGES

— PROGRAMS 2716's IN 16 SECONDS —
— PROGRAMS 2764's IN 64 SECONDS —

• Programs, validates, and checks for properly erased EPROMs • Emulates PROMs or EPROMs • RS232C Computer Interface for editing/program loading • Loads data into RAM by keyboard • Changes data in RAM by keyboard • Loads RAM from an EPROM • Compares EPROMs for content differences • Copies EPROMs • Power Input: 115VAC, 60Hz, ◄ 10W power consumption • Enclosure: Color-coordinated, light tan panels w/molded mocha brown end pieces • Size: 15-5/8"L x 8¾"D x 3½"H • Wt.: 5¾ lbs.

JE664-A EPROM Programmer $995.00
Assembled & Tested (Includes JM16A Module)

JE665 — RS232C INTERFACE OPTION — The JE665 RS232C Interface Option implements computer access to the JE664's RAM. Sample software written in BASIC provided for TRS-80® Model I, Level II Computer. Baud rate: 9600. Word Lgth: 8 bits - odd parity. Stop bits: 2. Option may be adapted to other computers.

JE664-ARS EPROM Prog. w/JE665 Option $1195.00
Assembled and Tested (Includes JM16A Module)

EPROM JUMPER MODULES — The JE664's JUMPER MODULE (Personality Module) is a plug-in Module that pre-sets JE664 for proper programming pulses to the EPROM & configures EPROM socket connections for that particular EPROM.

Part No.	EPROM	EPROM MANUFACTURER	PRICE
JM08A	2708	AMD, Motorola, National, Intel, TI	$14.95
JM16A	2716, TMS2516	Intel, Motorola, National, NEC, TI	$14.95
JM16B	TMS2716	Motorola, TI (+5,-12,+12)	$14.95
JM32A	TMS2532	Motorola, TI	$14.95
JM32B	2732	AMD, Fujitsu, NEC, Hitachi, Intel	$14.95
JM32C	2732A(21V)	Fujitsu, Intel	$14.95
JM64A	MCM68764, MCM68L764	Motorola	$14.95
JM64B	2764	Intel	$14.95
JM64C	TMS2564	TI	$14.95
JM64D	HN482764G-4	Hitachi (21V)	$14.95

iii's Black Hole EPROM Eraser

9 Chips — 8 Minutes

The Black Hole EPROM Eraser will completely and safely erase 9 EPROMs in less than 8 minutes. The Black Hole is a fully automatic cassette loading eraser featuring U-shaped 4000 hr. UV lamps mounted in a special ALZAK (UV reflectivity of .9) parabolic light tunnel. In operation, the user slips in an anti-static Bug Box (3 ea. incl.) containing the EPROMs to be erased into the loading slot on the front panel of Black Hole. The rest is fully automatic. The Black Hole latches the Bug Box into place, turns on the UV lamps and starts its fully solid state (CMOS) UV integration dose timer. The percentage erasure time is monitored and displayed on a front panel LED readout. At the end of the erase cycle, the Black Hole ejects the Bug Box containing the 9 erased EPROMs and turns off power.

PART NO.		PRICE
ULV-008	Replacement Lamp for ERS-008	$29.95
ERS-008	Eraser, Auto Eject & LED Readout	$249.95

IBM MEMORY EXPANSION KIT

SAVE HUNDREDS OF $$$ BY UPGRADING MEMORY BOARDS YOURSELF!

Most of the popular memory boards allow you to add an additional 64K, 128K, 192K, or 256K. The IBM64K Kit will populate these boards in 64K byte increments. The kit is simple to install — just insert the nine 64K RAM chips in the provided sockets and set the two groups of switches. Directions are included.

IBM64K (Nine 200ns 64K RAMs) $59.95

EXPAND YOUR MEMORY

TRS-80 to 16K, 32K, or 48K

**Model 1 =	From 4K to 16K Requires (1) One Kit	
Model 3 =	From 4K to 48K Requires (3) Three Kits	
Color =	From 4K to 16K Requires (1) One Kit	

**Model 1 equipped with Expansion Board up to 48K Two Kits Required
— One Kit Required for each 16K of Expansion —

TRS-16K3 *200ns	for Color & Model III	$12.95
TRS-16K4 *250ns	for Model I	$10.95

TRS-80 Color 32K or 64K Conversion Kit

Easy to install kit comes complete with 8 ea. 4164-2 (200ns) 64K dynamic RAMs & conversion documentation. Converts TRS-80 color computers with E circuit boards, & all new color computers to 32K. Minor modifications of 32K memory will allow the use of all the 64K of the dynamic RAM providing you have a FLEX DOS operating system.

TRS-64K2 . . . . $54.95

5¼" Mini-Floppy Disk Drive

Pertec Computer Corp.

FOR TRS-80 MODEL I · COLOR COMPUTER

Features single or double density. Recording mode: FM single, MFM double density. Seek time: 25msec. track to track. Power: +12VDC (±0.6V) 1.6A max., +5VDC (±0.25V) 0.8A max. Unit as pic. at right does not incl. case, power supply, cables). 30-pg. data book incl. Wt. 3½ lbs. Size: 5¾"W x 8"D x 3¼"H.

Part No. *Limited Quantity!*	Price
FD200 — Single-sided, 40 tracks, 250K bytes capacity	$179.95
FD250 — Double-sided, 35 tracks, 438K bytes capacity	$199.95

8" FLOPPY DISK DRIVE

Siemens

- Shugart 801R compatible
- Single-Sided
- 77 Tracks
- 400/800K Bytes Capacity
- Industry Standard

The **FDD100-8 8" Floppy Disk Drive** (Industry Standard) features single or double density. Recording mode: FM single, MFM double density. Transfer rate: 250K bits/sec. single density; 500K bits/sec. double density. The FDD100-8 is designed to work with the single-sided soft sectored IBM Diskette I, or eq. disk cartridge. Power: 115VAC @ 50-60Hz, +24VDC @ 1.7 amps max., +5VDC @ 1.2 amps max. Unit as pictured above (does not include case, power supply, or cables). Size: 8.55"W x 14"L x 4.5"H. Weighs 12 lbs. Incl. 96-pg. manual.

Part No.	Price
FDD100-8	**$169.95 ea.**

Circle 219 on inquiry card.

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NOT JUST AN ORDINARY SALE! WE HAVE *SLASHED PRICES TO THE BONE* AS OUR WAY OF THANKING YOU, OUR VALUED CUSTOMERS FOR 6 YEARS OF LOYALTY. WE'VE CONTINUOUSLY GROWN AND EXPANDED BY OFFERING YOU THE BEST VALUE FOR YOUR MONEY WITH THE BEST AFTER-SALE SUPPORT

AT LAST! CP/M 68K®!!!

CompuPro® SYSTEMS

CPU BOARDS

68K - 68000 16 BIT CPU

16 bit 8 or 10 MHz on-board sockets for 2716, 2732, or 2764 EPROMs for up to 8K x 16 of memory

Part No.	Description	List Price	Our Price
BTGBT184A	A&T 8MHz	$695.00	$512.95
BTGBT184C	CSC 10MHz	$850.00	$765.00

CP/M® 68K NOW AVAILABLE!!

Now CompuPro and Digital Research bring you CP/M for the 68000!!

BTGBTCPM68K	68000 CP/M®		$350.00

FORTH OPERATING SYSTEM FOR 68K CPU

Requires a DISK 1, 64K of CompuPro memory, and an INTERFACER 3 or 4

BTGBT68KOS	FORTH operating system		$200.00

CO-PROCESSOR 8086/8087

16 bit 8 or 10 MHz 8086 CPU with sockets for 8087 and 80136

BTGBT186A	A&T 8MHz 8086 only	$ 750.00	$494.95
BTGBT186C	CSC 10MHz 8086 only	$ 850.00	$764.89
BTGBT186A87	A&T with 8087 option	$1050.00	$939.00
BTGBT186C87	CSC with 8087 option*	$1150.00	$1065.00

*8087 Limits clock speed to 5MHz

DUAL PROCESSOR 8085-8088

6 or 8 MHz provides true 16 Bit Power with a standard 8 bit S-100 bus.

BTGBT1612A	A&T 6MHz	$495.00	$318.97
BTGBT1612C	CSC 6/8 MHz	$595.00	$497.87

CPUZ - Z80B CPU NOW 6MHz!

3/6 MHz Z80B CPU with 24 Bit Addressing.
FASTEST Z80 CPU AVAILABLE!

BTGBT160A	3/6 MHz A&T	$325.00	$228.95
BTGBT160C	3/6 MHz CSC	$425.00	$374.87

DISK CONTROLLERS

DISK 1 DMA FLOPPY CONTROLLER

Fast DMA, Soft Sector, Controls Up to Four 8" or 5¼" Single or Double Density Drives!

BSPDB171ACPM	A&T w/CPM 2.2® & BIOS	$670.00	$489.00
	When purchased w/two 8" disk drives only		$450.00
BTGBT171CCPM	CSC w/CP/M 2.2® & BIOS	$770.00	$595.00
BTGBT171A	Disk 1 Controller A&T	$495.00	$368.95
BTGBT171C	Disk 1 Controller CSC	$595.00	$550.00
BTGBTCPM80	CP/M 2.2® for Z80/8085 w/manual & BIOS 8" S/D disk		$148.95
BTGBTCPM86	CP/M 2.2® for 8086 w/manuals & BIOS 8" S/D disk		$258.95

DISK 2/SELECTOR CHANNEL HARD DISK CONTROLLER

Fast DMA 2 board set controls 4 Shugart 4000 series or Fujitsu 2300 type drives. Includes CP/M 2.2®.

BTGBT177A	Assembled & Tested	$795.00	$568.95
BTGBT177C	CSC	$895.00	$850.00

M-DRIVE/H HARDWARE LOGICAL DISK SYSTEM

Interfaces through two I/O ports, and runs at 10MHz IEEE 696 compatible. Requires any CompuPro CPU and a DISK 1. Each board contains 512K of fast, low power (900mA) RAM, with parity checking.

BTGBT197A	M-DRIVE/H w/software, A&T	$1895.00	$1249.95
BTGBT197C	M-DRIVE/H w/software, CSC	$2095.00	$1495.00

STATIC RAM

RAM 17 - 64K CMOS STATIC RAM

12 MHz, RAM 17, 2 Watt, DMA Compatible 24 Bit Addressing

BTGBT175A64	64K A&T 12MHz	$499.00	$460.00
BTGBT175C64	64K CSC 12MHz	$599.00	$550.00

RAM 16 - 32K x 16 BIT CMOS STATIC RAM

8 and/or 16 Bit 12MHz, RAM 16, 32K x 16 or 64K x 8 IEEE/696 16 Bit 2 Watt, 24 Bit Addressing

BTGBT180A	64K A&T 12MHz	$550.00	$510.00
BTGBT180C	64K CSC 12MHz	$650.00	$610.00

RAM 21 - 128K STATIC RAM

816 RAM 21 12MHz, 128K x 8 or 64K x 16 IEEE/696 8 or 16 Bit, 1.2 Amps, 24 Bit Addressing

BTGBT190A	128K A&T	$1095.00	$858.95
BTGBT190C	128K CSC	$1245.00	$1125.00

CompuPro® SYSTEMS

I/O BOARDS

SYSTEM SUPPORT 1 MULTIFUNCTION BOARD

Serila port (software prog. baud), 4K RAM included, 15 levels of interrupt, real time clock, optional math processor.

Part No.	Description	List Price	Our Price
BTGBT162A	Assembled & Tested	$450.00	$308.95
BTGBT162C	CSC	$550.00	$495.00
BTGBT8231	Math Chip		$195.00
BTGBT8232	Math Chip		$195.00
BTGBT162AM1	A&T w/8231 Math Chip	$645.00	$538.95
BTGBT162CM1	CSC w/8231 Math Chip	$745.00	$670.00
BTGBT162AM2	A&T w/8232 Math Chip	$645.00	$538.95
BTGBT162CM2	CSC w/8232 Math Chip	$745.00	$670.89

MPX CHANNEL BOARDS

I/O Multiplexer, using 8085A-2 CPU on board w/16K RAM

BTGBT166A16	Assembled & Tested	$649.00	$584.89
BTGBT166C16	CSC	$749.00	$674.89

INTERFACER 1

Two Serial I/O

BTGBT133A	Assembled & Tested	$295.00	$198.95
BTGBT133C	CSC	$370.00	$329.00

INTERFACER 2

Three parallel, one serial I/O board

BTGBT150A	Assembled & Tested	$325.00	$249.00
BTGBT150C	CSC	$399.00	$359.00

INTERFACER 3

Eight-channel multi-user serial I/O board

BTGBT1748A	Assembled & Tested	$699.00	$448.95
BTGBT1748C	CSC 200 hr. 8 port	$849.00	$748.89
BTGBT1745A	Assembled & TEsted	$599.00	$518.95
BTGBT1745C	CSC 200 hr. 5 port	$699.00	$628.89

INTERFACER 4

Three Serial, 1 Parallel, 1 Centronics Parallel

BTGBT187A	Assembled & Tested	$450.00	$314.87
BTGBT187C	CSC	$540.00	$414.87

S-100 MOTHERBOARDS

Active Termination, 6-12-20 Slot

BTGBT153A	A&T 6 slot (2 lbs.)	$140.00	$125.00
BTGBT153C	CSC 6 slot (2 lbs.)	$190.00	$155.00
BTGBT154A	A&T 12 slot (3 lbs.)	$175.00	$155.00
BTGBT154C	CSC 12 slot (3 lbs.)	$240.00	$220.00
BTGBT155A	A&T 20 slot (4 lbs.)	$265.00	$235.00
BTGBT155C	CSC 20 slot (4 lbs.)	$340.00	$310.00

CCS California Computer Systems

Z80 CPU 2 or 4MHz

On board RS232 Serial port, On board 2K Monitor, ROM, Power on jump to any location in 64K, LED status indicators for ROM select, halfstate and interrupts.

BTCCS2810A	Z80A 4MHz CPU A&T	$325.00	$258.95

CCS271901

BTCCS271901	2 Serial, 2 Parallel, A&T	$360.00	$288.95

CCS27201

BTCCS272001	4 Port Parallel, A&T	$275.00	$218.95

CCS271001

BTCCS271001	4 Port Serial, A&T	$325.00	$278.95

CCS2830

BTCCS283001	Assembled & Tested	$550.00	$428.95

CCS206601

64K Dynamic S-100 RAM. Cromemco CROMIX™ Compatible.

BTCCS206601	Assembled & Tested	$450.00	$425.00

CCS2422A

Floppy disk controller w/CP/M 2.2®

BTCCS2422A	Assembled & Tested	$475.00	$338.95

Circle 322 on inquiry card.

SSM

IO5

2 Serial, 3 Parallel S-100 Interface

Part No.	Description	List Price	Our Price
BTSSMIO5A	Assembled & Tested	$329.00	$289.89

IO8

8 Port Serial I/O S-100 Board

BTSSMIO8A	Assembled & Tested	$550.00	$450.00

IO4

2 Serial, 2 Parallel I/O S-100 Board

BTSSMIO4A	Assembled & Tested	$290.00	$245.00

2708/2716 EPROM PROGRAMMER & EPROM BOARD

Programs 2708 and 2716 EPROMs. Holds 4 2708s (4K) or 4 2716s (8K)

BTSSMB8A	Assembled & Tested	$265.00	$219.87

DUAL

NON VOLATILE CMOS RAMS

8, 16, or 32K. 8 or 16 Bit Data. Battery Backup On Board 6MHz, Bank Selectable

BTDULCMEM8	8K A&T	$495.00	$450.00
BTDULCMEM16	16K A&T	$595.00	$550.00
BTDULCMEM32	32K A&T	$695.00	$650.00

256K DYNAMIC MEMORY

256K, 230 ns access time, 2 x 128K organization, 24 bit addressing, parity error detection.

BTDULDMEM256K	Assembled & Tested	$1295.00	$1195.00

32/64K EPROM BOARD

8 or 16 bit data, holds 2716s (32K), or 2732s (64K)

BTDULEPROM32	For 2716s A&T	$295.00	$275.00
BTDULEPROM64	For 2732s A&T	$295.00	$275.00

A/D CONVERTER

12 Bit Resolution 16 or 32 Channel Input

BTDULAIM12	Assembled & Tested	$695.00	$625.00
BTDULAIM12B	Without instru. Amp	$645.00	$598.00

D/A CONVERTER

4 Channel, 12 Bit, 3 Output Modes

BTDULAOM12	Assembled & Tested	$695.00	$618.95

SIERRA DATA SCIENCES

S-100 SBC BOARD

Z80A 4MHz, 2 Serial RS232 interfaces, 1 parallel interface, 64K RAM, Floppy Disk Controller, provisions for one 2732 EPROM — ALL ON THIS ONE BOARD!!

BTSDSSBC	Z80A SBC A&T	$895.00	$655.00
BTSDSCPM	CP/M® Operating System on 8" disk		$150.00
BTSDSTURBDS	Single User TurboDos™ on 8" disk		$450.00
BTSDSTURBDM	Multi-User TurboDos™ on 8" disk		$750.00
BTMCP12231	36 MByte Hard Disk (45 lbs.)	$3695.00	$3250.00

S-100 Z80A SLAVE SBC

Z80A 4MHz, 2 RS232 Serial ports, 4 parallel ports, 64K RAM, EPROM Programmer. Used in multi-user computer system with SDSSBC.

BTSDSSBCSE	Slave Z80 SBC A&T	$825.00	$565.00

Intercontinental Micro Systems

Z80A DMA SBC & Z80B SLAVES

S-100 IEEE/696 COMPATIBLE - 1 YEAR WARRANTY!

CPZ-48000 FEATURES:

- 4MHz Z80A, 64K RAM
- Floppy disk personality card included for 5¼" or 8" floppy disk drives
- RS232 personality card included
- Two serial - two parallel I/Os

SLAVE PROCESSOR

- Z80 4 or 6MHz CPU (specify at time of order)
- Two serial - two parallel I/Os
- 64K RAM
- TURBODOS compatible

Part Number	Description	List Price	SALE PRICE
BTICMCPZ480008	SBC for 8" floppy	$995.00	$895.00
BTICMCPZ480005	SBC for 5¼" floppy	$995.00	$895.00
BTICM256KMB	256 KByte RAM	$995.00	$895.00
BTICMCPS4X	Z80A Slave 4MHz	$475.00	$440.00
BTICMCPS6X	Z80B Slave 6MHz	$550.00	$495.00
BTICMRS232	RS232 Personality Card		$ 25.00
BTICMCENTD	Centronics Parallel Personality Card		$ 28.00
BTICM8FDC	8" Floppy Disk Personality Card		$ 36.00
BTICM5FDC	5¼" Floppy Disk Personality Card		$ 33.00
BTICMCLKCAL	Clock Calendar		$ 48.00

RETAIL STORE PHONE NUMBERS: (Chatsworth:) (213) 709-5464 - (Irvine:) (714) 660-1411

PRIORITY ONE IS NUMBER 1!

OTHERS COME AND GO, WHILE WE HAVE BECOME THE LARGEST MAIL-ORDER DISTRIBUTOR IN THE MICRO-COMPUTER INDUSTRY. ORDER WITH CONFIDENCE. WHEN YOU HAVE A QUESTION, WE'LL BE HERE NEXT WEEK, NEXT MONTH AND NEXT YEAR! WE'RE NUMBER 1 AND STILL TRYING HARDER!

S-100 MAINFRAMES

PARADYNAMICS

BTPDN2018D	18 slot desk top (45 lbs.)	$660.00
BTPDN2018R	18 slot rack mount (45 lbs.)	$695.00
BTPDN2818S	18 slot w/power-seq., floor standing (shipped freight collect)	$1195.00
BTPDN2818	Same as above w/no power up seq. (Shipped freight collect)	$1150.00

SIERRA DATA SCIENCES

BTSDSMF	12 slot mainframe (30 lbs.)	$595.00
BTSDSWNMCP6	Same as above w/no power up seq. (Shipped Freight Collect)	$595.00

Q.T. COMPUTER

BTQTCMF	Mainframe / no motherboard (45 lbs.)	$305.00
BTQTCMF12	12 slot mainframe (45 lbs.)	$469.00
BTQTCMF18	18 slot mainframe (45 lbs.)	$499.00
BTQTCMF22	22 slot mainframe (45 lbs.)	$530.00
BTQTCMFMD	No motherboard cutouts for two 5¼" drives (45 lbs.)	$345.00
BTQTCMFMD6	6 slot, two 5¼" cutouts (45 lbs.)	$530.00
BTQTCMFMD12	12 slot, two 5¼" cutouts (45 lbs.)	$560.00
BTQTCMFDD6	6 slot, two 8" cutouts (48 lbs.)	$530.00
BTQTCMFDD8	8 slot, two 8" cutouts (48 lbs.)	$595.00
BTQTCMFDD12	12 slot, two 8" cutouts (48 lbs.)	$625.00

COMPUPRO

BTGBTENC20DK	20 slot desk top (Sh. Freight Collect)	$695.00
BTGBTENC20RM	20 slot desk top (Sh. Freight Collect)	$795.00

CVT POWER SUPPLY

NEW! **Power Supply Specifications:** **NEW!**

For 12 Slot MICROFRAMES: 8V @ 17A, ±16V @ 2A
For 22 slot MICROFRAMES: 8V @ 30A, ±16V @ 4A

AC input may range from 70 - 140 VAC

Part No.	Description	Price
BTHDLMCS112	12 slot desk top (Sh. Wt. 26 lbs.)	$737.00
BTHDLMCS122	22 slot desk top (Sh. Wt. 44 lbs.)	$881.00
BTHDLRM12	12 slot rack mount (Sh. Wt. 38 lbs.)	$879.00
BTHDLRM22	22 slot rack mount (Sh. Wt. 46 lbs.)	$1036.00

12 SLOT MICROFRAME WITH CUTOUTS FOR THREE 5¼" DRIVES

This MICROFRAME is for applications where space is a limitation. The power supply supports the S-100 bus, and three floppy or Winchester disk drives. Each power supply output for the drives are ±5V @ 4A, and +12V @ 8A. The S-100 supply provides +8V @ 15A and ±16V @ 2A.

BTHDLTF12	12 slot desk top (Sh. Wt. 41 lbs.)	$960.00
BTHDLRF12	12 slot rack mount (Sh. Wt. 46 lbs.)	$1053.00

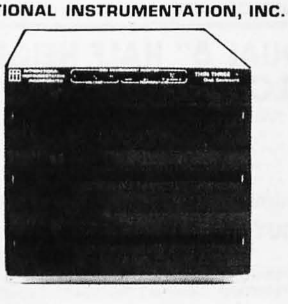
8" DISK DRIVE ENCLOSURE

The power supply of this enclosure has the capability to drive 4 half-height floppy disk drives, 2 Winchester hard disk drives, or a combination of 2 half-height floppies and a Winchester drive in the same cabinet. Power supply outputs are +5V @ 7A, -5V @ 3A, ±12V @ 4A, and +24V @ 8A.

BTHDLDDE8	Desk top disk enclosure (45 lbs.)	$910.00
BTHDLDDE8R	Rack mount disk enclosure (45 lbs.)	$1015.00

INTERNATIONAL INSTRUMENTATION, INC.

THIN THREE 8" DRIVE CABINET



- Supports 3 half-high 8" disk drives • 5V @ 6A, -5V @ 1A, 24V @ 6A
- One AC power connector for one full size drive • 5V output over-voltage protected • Optional disk environmental monitor is available to monitor and alarm you to internal temperature reaching dangerous levels

Part No.	List Price	SALE PRICE
BTIIIUDETTT	$495.00	$375.00
WITH DISK ENVIRONMENTAL MONITOR:		
BTIIIUDETTTEM	$584.95	$425.00

DUAL QUME 8" FLOPPY DRIVE, CABINET, DMA S-100 CONTROLLER, AND CP/M® From CompuPro

$1595.00

BTPDBGBTSYS206 (Shipped freight collect)

ABSOLUTELY THE MOST COST EFFECTIVE DISK SUBSYSTEM EVER OFFERED BY PRIORITY ONE ELECTRONICS

YOU SAVE $1419.77!!

		List Price
• 2 Double sided 8" QUME DT8 disk drives		
• DMA Floppy Controller (controls up to 4 drives)	1 GBT206SP	$2325.00
• CP/M 2.2® w/BIOS written for the Disk 1 Controller	1 GBT171A	$495.00
• Cabinet includes power supply & internal data cable	1 GBTCPM80	$175.00
• External data cable included	1 PGC50S60S	$ 19.77
		$3014.77

SAVE $1030.00!!

CABINET AND 2 QUME DT8 DOUBLE SIDED DRIVES PROVIDE 2.4 MBYTES OF MASS STORAGE!! **$1295.00**
BTGBT206SP (Sh. Wt. 50 lbs.) List Price: $2325.00

CompuPro STATIC RAM SALE!!

IEEE/696 S-100 - ULTRA LOW POWER!

256K RAM 22

- Fully static design eleiminates timing problems associated with Dynamic RAMs (<4 Watts)
- Guaranteed to work with any IEEE/696 S-100 DMA device
- 24 bit extended addressing
- 8 or 16 bit data
- Single 5V operation
- Assembled and Tested

BTGBT198A

NEW!

12 MHz
SUPER SALE PRICE:
$1500.00 EACH, WHEN YOU BUY 2 OR MORE
$1595.00 Each

128K RAM 21

- Fully static design uses less power than dynamics (1.2A typical)
- 24 bit extended addressing
- 8 or 16 bit data
- 16K window deselect
- Switch selectable PHANTOM disable
- Fully DMA compatible
- Assembled and Tested

BTGBTRAM21 LIST PRICE: $1295.00

12 MHz
SUPER SALE PRICE:
$650.00 EACH, WHEN YOU BUY 2 OR MORE
$695.00 Each

64K 10MHz LOW POWER S-100 IEEE/STATIC RAMS

RAM 17
64K 8 BIT / 24 BIT ADDRESS
BTGBTRAM17 List Price: $499.00
$299.00

RAM 16
64K 8 or 32K 16 BIT / 24 BIT ADDRESS
BTGBTRAM16 List Price: $550.00
$325.00

MasterCard **PRIORITY ONE ELECTRONICS** VISA
9161 Deering Ave., Chatsworth, CA 91311

ORDER TOLL FREE (800) 423-5922 - CA, AK, HI CALL (213) 709-5111

Terms. U.S. VISA, MC, BAC, Check, Money Order, U.S. Funds Only. CA residents add 6½% Sales Tax. MINIMUM PREPAID ORDER $15.00. Include MINIMUM SHIPPING & HANDLING of $3.00 for the first 3 lbs. plus 40¢ for each additional pound. Orders over 50 lbs. sent freight collect. Just in case, include your phone number. Prices subject to change without notice. We will do our best to maintain prices through August, 1983. Many quantities are limited. Sorry, no rainchecks, no refunds or exchanges on sale merchandise. Credit Card orders will be charged appropriate freight. Sale prices for prepaid orders only. We are not responsible for typograpical errors.

Circle 322 on inquiry card.

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SIEMENS FDD100-8

8" FLOPPY DISK DRIVE

SINGLE SIDED, DOUBLE DENSITY
SHUGART 801R COMPATIBLE

90 DAY WARRANTY!

ONCE AGAIN, YOU RECEIVE THE BENEFIT OF OUR UNEQUALLED PURCHASING POWER!

$175.00 each

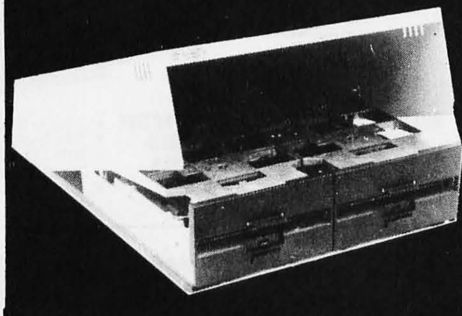
CALL for 10+

OEM INQUIRIES INVITED
(Include $7.00 per drive for shipping)
BTSIEFDD1008

ORDER NOW AND $AVE!

BUY DRIVE & CABINET TOGETHER AND $SAVE!!

DUAL 8" SIEMENS FDD1008
DUAL 8" CABINET POWER SUPPLY AND INTERNAL POWER CABLES
(Include $30.00 for shipping)



- Positive Pressure Filter Cooling
- Power Supply: 4A@+5V, 3A@+24V 1A @ -5V
- Each output is individually fused
- Hinged to for easy access
- Heavy non-flex .090 aluminum base
- Modular power connectors

IF BOUGHT SEPARATELY: $890.00
ANNIVERSARY SALE PRICE:

$625.00

BTPDBIIISIE (Include $30.00 for shipping)
BTIIIFDE002 CABINET ONLY (Sh. Wt. 38 lbs.) ***$295.00***

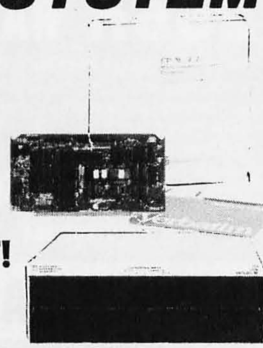
S-100 DUAL 8" SUBSYSTEM

BTCCS2422A	S-100 Disk Controller with CP/M 2.2®	1	$338.00
BTSIEFDD1008	Siemens Double Density 8" drive	2	$350.00
BTIIIFDE002	Dual Horizontal Cabinet with Power Supply	1	$295.00
	and Data Cable	1	$ 35.00
			$1018.95

SAVE $43.95!!

$975.00

(Include $30.00 for shipping)



DON'T MISS OUT!
Order No. BTPDBSIESUB1

DISK DRIVES

TANDON 5¼" HARD DISK

BTTNDTM501	1 platter 6 Mbyte (Sh. Wt. 9 lbs.)	**$749.00**
BTTNDTM502	2 platter 12 Mbyte (Sh. Wt. 9 lbs.)	**$895.00**
BTTNDTM503	3 platter 19 Mbyte (Sh. Wt. 9 lbs.)	**$1049.00**

DUAL HARD DISK ENCLOSURE

BTIIIHD5002	For above drives	**$395.00**

TANDON 5¼"

BTTNDTM1001	1 Sided 48 TPI	**$225.00**	**2 FOR $195.00 each**
BTTNDTM1002	2 Sided 48 TPI	**$260.00**	**2 FOR $235.00 each**
BTTNDTM1003	1 Sided 96 TPI	**$275.00**	**2 FOR $250.00 each**
BTTNDTM1004	2 Sided 96 TPI	**$390.00**	**2 FOR $365.00 each**

(Shipping Weights on above items: 5 lbs. each)

MPI 5¼" FULL HEIGHT

BTMPI51*	1 Sided 48 TPI	***$200.00***
BTMPI52*	2 Sided 48 TPI	***$270.00***
BTMPI91*	1 Sided 96 TPI	***$275.00***
BTMPI92*	2 Sided 96 TPI	***$400.00***

*Replace with an "**M**" for the MPI style bezel, or with an "**S**" for Shugart style bezel. (Shipping Weight: 5 lbs.)

MPI 5¼" HALF HEIGHT

BTMPI501	1 Sided 48 TPI (Sh. Wt. 4 lbs.)	***$260.00***
BTMPI502	2 Sided 48 TPI (Sh. Wt. 4 lbs.)	***$300.00***
BTMPI901	1 Sided 96 TPI (Sh. Wt. 4 lbs.)	***$300.00***
BTMPI902	2 Sided 96 TPI (Sh. Wt. 4 lbs.)	***$355.00***

SHUGART 8" FULL HEIGHT

BTSHU801R	1 sided (18 lbs.)	***$369.00***

QUME 8" FULL HEIGHT

BTQMEDT8	2 sided (18 lbs.)	***$480.00*** ***2 FOR $460.00 ea.***

MITSUBISHI 8" FULL HEIGHT

BTMITM289463B	2 sided (18 lbs.)	***$380.00***

MPI 8" FULL HEIGHT

BTMPI41S	1 sided (11 lbs.)	***$380.00***
BTMPI42S	2 sided (11 lbs.)	***$460.00***

MPI 8" DUAL HALF HEIGHT

(SAME SIZE AS ONE FULL HEIGHT)

BTMPI41D	1 sided (22 lbs.)	***$760.00***
BTMPI42D	2 sided (22 lbs.)	***$870.00***

TANDON 8" HALF HEIGHT

BTTNDTM8481	1 sided (9 lbs.)	***$395.00*** **2 FOR $375.00 ea.**
BTTNDTM8482	2 sided (9 lbs.)	***$495.00*** **2 FOR 475.00 ea.**

MPI 8" HALF HEIGHT

BTMPI41M	1 sided (11 lbs.)	***$380.00***
BTMPI42M	2 sided (11 lbs.)	***$460.00***

5¼" DRIVE CABINETS

DTJMR1C5	Single 5¼" Cabinet (5 lbs.)	***$69.00***
BTJMR2C5	Dual 5¼" Cabinet (9 lbs.)	***$89.00***
BTJMR2C5C	JMR2C5 w/internal data cable (9 lbs.)	***$99.00***

OUR FINEST DUAL 8" DISK DRIVE CABINET!

FEATURES:

- Positive pressure forced air cooling for reliable disk drive operation
- AC input via 3 wire 7 foot international cord/socket set
- AC input EMI filtered to six amps to help prevent disk crashes due to power spikes and line noise
- 14 gauge main chassis
- Integral power supply with 5V @ 6A/-5V @ 1A/24V @ 6A
- Double-sided custom PC power board and supply
- Each DC supply and AC separately fused

Part No.		List Price	Our Price
BTIIIUDE004	(Sh. Wt. 40 lbs.)	$495.00	**$349.00**

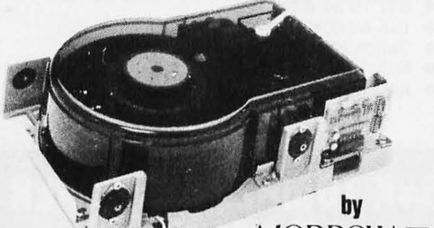
With augmented power supply to handle Tandon Slimline, or Winchester disk drives. Includes the disk environment monitor.

BTIIIUDE004AUG	(Sh. Wt. 40 lbs.)	$733.00	**$625.00**

With Disk Environment Monitor for cool, reliable operation.

BTIIIUDE004EM	(Sh. Wt. 40 lbs.)	$584.95	**$395.00**

S-100 HARD DISK SUBTYSTEMS



by MORROW

COMPLETE WITH S-100 CONTROLLER, CP/M 2.2® AND MICROSOFT BASIC V5.2

Part No.	Description	List Price	Our Price
BTMDSM20S	20 Mbyte 8"	$4495.00	**$3250.00**

(Shipping Weights: M20: 37 lbs.; M26 (3 boxes): 8, 26, & 45 lbs. each)

ADD-ON DRIVES

(Does not include software and controller)

BTMDSA8M10	10 Mbyte 8"	$2795.00	**$2050.00**
BTMDSA14M26	26 Mbyte 14"	$3495.00	**$2675.00**

(Shipping Weights: M10: 37 lbs; M26, (2 boxes): 26, & 45 lbs. each)

DUAL 8" HALF HEIGHT FLOPPY CABINET

- 24V @ 4A, 5V @ 3A -5V @ 800ma
- Fan cooled
- Socketed power connections
- All supplies regulated

		List Price	Our Price
BTIIIDTL002	Dual Thin Line Cabinet (12 lbs.)	$225.00	**$165.00**

BUY THE CABINET & DRIVES AND $AVE!

With 2 Tandon Thinlines

BTPDBIIITND1	Cabinet w/2 TNDTM8481 - 1 sided (30 lbs.)	**$ 885.00**
BTPDBIIITND2	Cabinet w/2 TNDTM8482 - 2 sided (30 lbs.)	**$1115.00**

With 2 MPI Slimlines

BTPDBIIIMPI1	Cabinet w/2 MPI41M - 1 sided (30 lbs.)	**$ 920.00**
BTPDBIIIMPI2	Cabinet w/2 MPI42M - 2 sided (30 lbs.)	**$1080.00**

Options

BTIIIDTLMPIKIT	MPI drive adaptor mounting kit (2 lbs.)	**$24.95**
BTIIIDCCSHU	Shugart / AC/DC power connector kit (2 lbs.) (For full size single SA801 or compatible drives)	**$14.95**

RETAIL STORE PHONE NUMBERS: (Chatsworth:) (213) 709-5464 - (IRVINE:) (714) 660-1411

Circle 322 on inquiry card

PRIORITY ONE IS NUMBER 1!

OTHERS COME AND GO, WHILE WE HAVE BECOME THE LARGEST MAIL-ORDER DISTRIBUTOR IN THE MICRO-COMPUTER INDUSTRY. ORDER WITH CONFIDENCE. WHEN YOU HAVE A QUESTION, WE'LL BE HERE NEXT WEEK, NEXT MONTH AND NEXT YEAR! WE'RE NUMBER 1 AND STILL TRYING HARDER!

APPLE II/IIe DISK DRIVES

Drive, Cartridges, DMA Controller, Cabinet and Power Supply

FULLY APPLE II COMPATIBLE

ADD-ON DRIVE

BTVIS3101 (Shipping Weight 6 lbs.) ***$229.00***

DISK DRIVE WITH CONTROLLER

BTVIS3111 (Shipping Weight 7 lbs.) ***$289.00***

BTVISAFDC Apple II Drive Controller ***$79.00***

6 MEGABYTE DISK SUBSYSTEM

BTVIS1840 List Price: $1549.00 **SALE: *$1299.00***

PRINTERS

star micronics • inc

COEX 80 F/T DOT MATRIX PRINTER

BTCOX80FT	Parallel Interface 80 cps (21 lbs.)	**$289.00**
BTCOX80FTSER	Serial Interface 80 cps (21 lbs.)	**$289.00**
BTCOXAPLINTP	Apple II Parallel Interface (1 lb.)	**$49.95**

star GEMINI 10 & 15

BTGEM10X	120 cps Parallel Int. 80 col. (20 lbs.)	**$319.00**
BTGEM15	100 cps Parallel Int. 132 col. (26 lbs.)	**$459.00**
BTGEMSERINT	Serial interface card for GEM10X and GEM15 (1 lb.)	**$85.00**

AXIOM — AXIOM CORPORATION — $229

BTAXMGP100A	30 cps 8 col. dot matrix (11 lbs.)	**$229.00**

OKIDATA

BTOKIDAT82AT	TRACTOR INCLUDED (25 lbs.)	**$449.00**
BTOKIDAT83AT	TRACTOR INCLUDED (35 lbs.)	**$729.00**
BTOKIDAT92AP	OKIDATA 92A Parallel (25 lbs.)	**$480.00**
BTOKIDAT92AS	OKIDATA 92A Serial (25 lbs.)	**$599.00**
BTOKIDAT92AT	OKIDATA92A Tractor (2 lbs.)	**$ 79.95**
BTOKIDAT93AP	OKIDATA93A parallel (35 lbs.)	**$830.00**
BTOKIDAT93AS	OKIDATA93A Serial (35 lbs.)	**$995.00**

MANNESMANN TALLY

LETTER QUALITY DOT MATRIX PRINTER

- 160 cps
- 40 cps (Letter quality)
- Serial & Parallel Interface
- Double wide characters
- Tractor and friction feed
- "Bullet-Proof" cast frame with metal cabinet

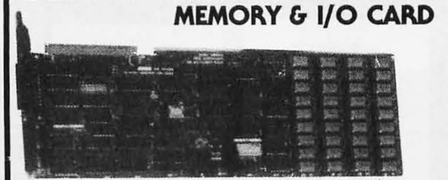
BTTALMT160L	160 cps 80 col (21 lbs.)	**$569.00**
BTTALMT180L	160 cps 132 col. (28 lbs.)	**$784.00**

QUME LETTER QUALITY PRINTER

BTQMES945	45 cps Sprint 9 (49 lbs.)	**$1789.00**
BTQMES955	55 cps Spring 9 (49 lbs.)	**$2195.00**
BTQMES1140	40 cps Sprint 11 (45 lbs.)	**$1389.00**
BTQMES11RS232	RS232 Module for Sprint 11 (3 lbs.)	**$ 99.00**
BTQMES11CENT	Centronics parallel for Sprint 11 (3 lbs.)	**$ 99.00**
BTQMES11IEEE488	IEEE488 Module for Sprint 11 (3 lbs.)	**$ 99.00**
BTQMES11IBM	IBM module for Sprint 11 (3 lbs.)	**$ 99.00**
BTQMEBDT	Bi-Directional Tractor (9 lbs.)	**$ 349.00**
BTQMEWB	Wire basket (2 lbs.)	**$ 85.00**
BTQMECSF	Cut Sheet Feeder (20 lbs.)	**$ 849.00**

IBM® MULTICARD

MEMORY & I/O CARD



- 64K RAM Expandable to 256K
- One RS232 Serial Port
- One Parallel Printer Port
- Real Time Clock Calendar with Battery Backup (Shipping Weight 1 lb.)

BTVIS025665 List Price: $595.00

ANNIVERSARY SALE PRICE:

$329.00

IBM® MAXICARD

PERSONAL COMPUTER RAM CARD

Vista POPULATED IN 64K, 256K, or 576K

- Runs at full speed with no wait states
- Parity can be disabled at User's option
- On board parity bit on each Byte
- Fully expanded, a full 576 KB on one card
- One board fills entire primary RAM address space available
- Full Vista 120 Day Warranty

64K *$219.00*
BTVIS057664 List Price: $379.00
SAVE $160.00!!

256K *$489.00*
BTVIS0576256 List Price: $789.00
SAVE $320.00!!

576K *$849.00*
BTVIS0576576 List Price: $1299.00
SAVE $450.00!!

* Available with 256K & 576K boards only (Sh. Wt. 6 lbs.)

(IBM is a trademark of International Business Machines)

5¼" FLOPPY DISKETTES

ULTRA MAGNETICS **DOUBLE DENSITY!** **LIFETIME WARRANTY!**

FEATURES:

- Includes reinforcement ring
- 100% Surface tested
- Write protect with tabs
- Lifetime warranty!

SINGLE SIDED

40 TRACKS — DOUBLE DENSITY

1 BOX OF 10:	***$ 25.00***
2 BOXES:	***$ 40.00***
10 BOXES:	***$180.00***

ORDERING INFORMATION

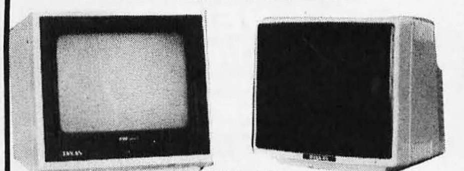
BTULT51401 Soft Sector
BTULT51410 10 Sector
BTULT51416 16 Sector

BTULT52401 Soft sector, 40 track, 2 sided
BTULT52410 10 sector, 40 track, 2 sided
BTULT52416 16 sector, 40 track, 2 sided

1 BOX OF 10	2 BOXES	10 BOXES
$35.00	***$60.00***	***$280.00***

MONITORS

COLOR MONITORS



TAXAN

Part No.	Description	List Price	Our Price
BTTAXRGB1	12" med. res. RGB (29 lbs.)	$399.00	**$328.95**
BTTAXRGB3	12" high res. RGB (29 lbs.)	$699.00	**$499.87**
BTTAX410-03	Apple II RGB int. w/cable (1 lb.)		**$125.00**
BTTAX410-80	Apple IIe & III 80 col. RGB int. (1 lb.)		**$179.00**
BTTAXIBMRGB	IBM PC™ RGB Cable (1 lb.)		**$19.00**
BTTAXRGBAPL	Apple IIe & III RGB Cable (1 lb.)		**$19.00**

SANYO

BTSYOVMC7013	13" NTSC w/sound (35 lbs.)	$650.00	**$349.00**
BTSYODM6113	13" RGB (35 lbs.)	$795.00	**$499.00**
BTSYOAVM255	25" RGB/NTSC (25" Monitor shipped freight collect)	$795.00	**$699.00**
BTSYODM8112CX	12" green (24 lbs.)	$260.00	**$159.00**

hp HEWLETT PACKARD — PERSONAL COMPUTATION DEALER

SERIES 10 PROGRAMMABLE CALCULATORS

Part No.	Description	List Price	Our Price
BT HP-10C	Scientific	$ 70.00	***$59.00***
BT HP-11C	Adv. scientific	$ 90.00	***$79.00***
BT HP-12C	Adv. financial	$120.00	***$99.00***
BT HP-15C	Adv. sci. w/matrix	$120.00	***$99.00***
BT HP-16C	Digital & Computer science	$120.00	***$99.00***

(Shipping Weights on above calculators: 3 lbs. each)

HP-41C/CV HANDHELD COMPUTER SYSTEM

BT HP-41C	Handheld computer	$195.00	***$159.00***
BT HP-41CV	Handheld computer w/5x the memory	$275.00	***$219.00***
BT HP82104A	Card reader	$195.00	***$159.00***
BT HP82153A	Optical Wand	$125.00	***$ 99.00***
BT HP82161A	Cassette drive	$450.00	***$349.00***
BT HP82162A	Thermal Printer	$450.00	***$349.00***
BT HP82163A	Video Interface	$225.00	***$179.00***

(Shipping Weights on above items: 5 lbs. each)

ENHANCEMENT MODULES:

BT HP82160A	HP-IL module	$125.00	***$95.00***
BT HP82170A	Quad RAM module	$ 75.00	***$59.00***
BT HP82180A	Extended functions/ memory module	$ 75.00	***$59.00***
BT HP82181A	Ext. memory module	$ 75.00	***$59.00***
BT HP82182A	Time module	$ 75.00	***$59.00***

(Shipping Weights on above items: 1 lb. each)

HP-75C PORTABLE COMPUTER

BT HP-75C (Sh. Wt. 9 lbs.) List Price: $995.00 ***$795.00***

ACCESSORIES FOR HP-75C

BT HP00075-15014	VisiCalc® ROM for HP-75C	**$195.00**
BT HP00075-15019	Text formatter for HP-75C	**$ 95.00**
BT HP00075-15012	Surveying Pac for HP-75C	**$295.00**
BT HP00075-15015	Math Pac for HP-75C	**$145.00**
BT HP00075-15035	Data Communications Pac for HP-75C	**$145.00**
BT HP00075-13016	Graphics solutions book	**$ 45.00**

(Shipping weights for above items: 1 lb. each)

VISA — ***PRIORITY ONE ELECTRONICS*** — MasterCard

9161 Deering Ave., Chatsworth, CA 91311

ORDER TOLL FREE (800 423-5922 - CA, AK, HI CALL (213) 709-5111

Terms: U.S. VISA, MC, BAC, Check, Money Order, U.S. Funds Only. CA residents add 6½% Sales Tax. MINIMUM PREPAID ORDER $15.00. Include MINIMUM SHIPPING & HANDLING of $3.00 for the first 3 lbs. plus 40¢ for each additional pound. Orders over 50 lbs. sent freight collect. Just in case, please include your phone number. Prices subject to change without notice. We will do our best to maintain prices through August, 1983. Credit Card orders will be charged approriate freight. Sale prices for prepaid orders only. We are not responsible for typographical errors.

Circle 322 on inquiry card.

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SIXTH ANNIVERSARY SALE!

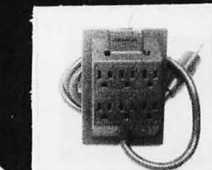
NOT JUST AN ORDINARY SALE! WE HAVE *SLASHED PRICES TO THE BONE* AS OUR WAY OF THANKING YOU, OUR VALUED CUSTOMERS FOR 6 YEARS OF LOYALTY. WE'VE CONTINUOUSLY GROWN AND EXPANDED BY OFFERING YOU THE BEST VALUE FOR YOUR MONEY WITH THE BEST AFTER-SALE SUPPORT

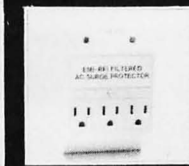
THE LEMON™ SOURS SURGES!

NEW! From EPD

Electronic Protection Devices

The LEMON, LIME, ORANGE, and PEACH are solid state and EMI-RFI noise filters designed to protect all mini and micro computers, word processors, printers, disc drives, and other computer-controlled equipment that is plugged into an AC power line. There may be nothing more terrifying than to lose all of your software or data files due to a high voltage spike or noise from an adjacent elevator, air conditioner, or any other high powered equipment being operated in the nearby area. With a LEMON, LIME, ORANGE, or PEACH, you can be sure that the FRUITS of your computer labor will be protected from most voltage spikes and EMI-RFI interferences.





AC SURGE PROTECTORS

Part No.	Description	List Price	Our Price
BTEPDLEMON	6 outlet wall mount	$59.95	$44.95
BTEPDLIME	6 outlet 4½" cord w/power switch	89.50	$69.95

(Shipping Weight: 4 lbs. each)

EMI-RFI FILTERED AC SURGE PROTECTOR

Part No.	Description	List Price	Our Price
BTEPDORANGE	6 outlet 4½" cord w/power switch	$139.95	$104.95
BTEPDPEACH	6 outlet wall mount	$97.50	$ 74.95

(Shipping Weight: 4 lbs. each)

TERMINALS

VISUAL 50

BEST BUY!

BTVSL50BW	Black & White 12"	$695.00 (41 lbs.)	$625.00
BTVSL50GN	Green Screen 12"	$770.00 (41 lbs.)	$655.00

FEATURE COMPARISON CHART

Feature:	VISUAL 50	Hazeltine Esprit	ADDS Viewpoint	Lear Siegler ADM-5	TeleVideo 910
Tilt & Swivel	YES	NO	NO	NO	NO
Detached Keyboard	YES	NO	YES	NO	NO
N-Key Rollover	YES	NO	YES	NO	NO
Audible Key Click	YES	YES	NO	NO	NO
Menu Set-Up Mode	YES	NO	NO	NO	NO
Status Line	YES	NO	NO	NO	NO
Full 5 Attribute Selection	YES	NO	NO	NO	YES
Smooth Scroll	YES	NO	NO	NO	NO
Line Drawing Character Set	YES	NO	NO	NO	NO
Block Mode	YES	YES	NO	NO	YES
Insert/Delete Line	YES	YES	NO	NO	YES
Bi-Directional Aux. Port	YES	YES	NO	YES	NO
Columnar Tabbing	YES	YES	NO	NO	YES
Independent RCV/TX Rates	YES	NO	NO	NO	NO
Answerback User Programmable	YES	NO	NO	OPT	NO

VISUAL 55 & 330

Same as above with additional insert/delete character, 12 uer programmable function keys, selectable scrolling region, programmable message framing codes, and Hazeltine 1510 compatibility.

BTVSL55GN	Green screen 12"	(Sh. Wt. 41 lbs.)		$689.00
BTVSL330GN	Green 12" CRT	(Sh. Wt. 41 lbs.)	$1200.00	$895.00
BTVSL33014GN	Green 14" CRT	(Sh. Wt. 41 lbs.)	$1250.00	$949.00

TELEVIDEO

BTPDBTLV9252P	w/2nd page memory kit FREE (A $95.00 Value)	$729.00
BTPDBTW9504P	w/2nd, 3rd, & 4th page memory kit FREE (A 285.00 Value) above items: 37 lbs. ea.	$929.00
BTTLV910	80 col. terminal (Sh. Wt. 37 lbs.)	$558.95
BTTLV970	14" 80/132 col. terminal (Sh. Wt. 40 lbs.)	$1019.00

LIBERTY ELECTRONICS

BTLIBF50	Freedom 50 (Sh. Wt. 30 lbs.)	$599.00	$474.00

ADDS

BTADDVWPR	Viewpoint 3A+ (30 lbs.)	$695.00	$575.00

QUME

NEW!!

BTQME102	80 Column Green (Sh. Wt. 30 lbs.)	$550.00
BTQME102AM	80 Column Amber (Sh. Wt. 30 lbs.)	$565.00
BTQME103	80/132 Column Green (Sh. Wt. 30 lbs.)	$765.00
BTQME109	22 function key, 80 col. Green (30 lbs.)	$749.00
BTQME108AM	22 function key, 80 col. Amber (30 lbs.)	$765.00

SUPER DMM SALE!

HITACHI
Hitachi Denshi, Ltd.

AUTO RANGING 3½ DIGIT LCD

- Eight measurement functions with auto ranging
- Data hold feature
- Continuity beeper
- Temperature measurements (except HITVR3550)
- .5 to .1% accuracy
- 10M input impedance
- 250V overload protection on all resistance functions
- 1100 VDC or 850 VAC overload protection on volt scales

Part No.	Description (Sh. Wt. 2 lbs.)	List Price	Our Price
BTHITVR3550	.5% Autoranging DMM	$127.00	$105.00
BTHITVR3525	.25% with temp	$157.00	$130.00
BTHITVR3510	.1% with temp	$187.00	$160.00
BTHIT6703	Soft carrying case		$15.00

FLUKE

BTFLU8022B	Handheld DMM .25% Accuracy	$144.00
BTFLU8021B	Handheld DMM .5% Accuracy w/cond.	$159.00
BTFLU8020B	Handheld DMM .1% Accuracy	$194.00
BTFLU8024B	Handheld DMM .1% Accuracy, Pk. & Hold	$249.00
	(Shipping Weights on above items: 2 lbs. each)	
BTFLU8010A	10A Tru RMS Bench DMM (6 lbs.)	$259.00
BTFLU8010A01	FLU8010A w/battery (6 lbs.)	$299.00
BTFLU8012A	Low Ohms Tru-RMS Bench (6 lbs.)	$339.00
BTFLU8012A01	FLU8012A w/battery (6 lbs.)	$379.00
BTFLU8060A	4½ Digit DMM w/Frequency Counter (2 lbs.)	$349.00
BTFLU8062A	4.5 digit Handheld DMM (2 lbs.)	$279.00
BTFLU8050A	4.5 digit True-RMS Bench DMM (6 lbs.)	$389.00
BTFLU8050A01	FLU8050A w/battery (6 lbs.)	$439.00
BTFLUC90*	Soft carrying case	($10.00) 1¢

KEITHLEY

BTKTH130	3.5 digit .5% Accuracy handheld DMM	$129.00
BTKTH131	3.5 digit .25% Accuracy handheld DMM	$139.00
BTKTH128	3.5 digit handheld DMM w/beeper	$139.00
BTKTH132C	3.5 digit handheld DMM w/thermometer (Cent.)	$199.00
BTKTH132F	3.5 digit handheld DMM w/thermometer (Far.)	$209.00
BTKTH135	4½ digit handheld DMM	$239.00
	(Shipping Weights for above items: 2 lbs. each)	
BTKTH169	3.5 digit bench LCD DMM	$189.00
BTKTH176	4.5 digit bench LCD DMM	$299.00
BTKTH179A	4.5 digit bench LED DMM	$359.00
BTKTH1911910	5.5 digit bench DMM	$870.00
BTKTH1911920	5.5 digit bench true RMS	$940.00
	(Shipping Weights for above items: 6 lbs. each)	
BTKTH1304*	Soft carrying case	($10.00) 1¢

BUY A SOFT CARRYING CASE FOR 1¢
***With the purchase of any Fluke or Keithly Handheld DMM!**

MODEMS

U.S. ROBOTICS

Part No.	Description	List Price	SALE PRICE
BTUSRADIAL212A	1200 baud Auto Orig/Answer	$599.00	$495.00
BTUSRPASSWORD	1200 baud Auto Orig/Answer	$449.00	$379.00
BTUSRTELPAC8	Password Comm. Software 8" CP/M		$ 79.00
BTUSRTELPAC5A	Password Comm. Software 5¼" Apple		$ 79.00
BTUSRMLNK300	Micro Link 300 Baud	$179.00	$159.00
BTUSRMLNK1200	Micro Link 1200 Baud	$449.00	$369.00
BTUSRALNK300	Auto Link 300 Baud	$219.00	$175.00
BTUSRALNK1200	Auto Link 1200 Baud	$499.00	$399.00

(Shipping Weights on above items: 4 lbs. each)

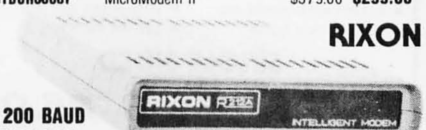
SEE PAGE 30 OF THIS MONTH'S BYTE FOR MORE INFORMATION

D.C. HAYES

BTDCH0400P	1200 Baud Smartmodem	$695.00	$514.95
BTDCH0200P	300 Baud Smartmodem	$279.00	$229.00
BTDCH0300P	Chronograph	$249.00	$199.00
BTDCH0100P	MicroModem 100	$399.00	$349.00
BTDCH0000P	MicroModem II	$379.00	$299.00

RIXON

1200 BAUD AUTO DIAL



DIRECT CONNECT MODEMS WITH 10 NUMBER MEMORY

BTRIXR212A	1200 Baud Stand Alone unit	$495.00	$475.00
BTRIXPC212A	1200 IBM PC™ modem (2 lbs.)	$495.00	$475.00
BTRIXPCCOM1	IBM PC™ Modem Software (1 lb.)		$ 89.00
BTPDBRIXIBM	IBM Modem & Software Together (3 lbs.)		$539.00

SEE PAGE 445 OF THE JULY ISSUE OF BYTE FOR MORE INFORMATION

MURA DIRECT CONNECT MODEM

$79.00

0 - 300 BAUD
MURA MM-100

- 0 - 300 Baud
- RS232C interface
- Full duplex
- Carrier detect indicator
- Bell 103 compatible
- Low voltage
- Originate/Answer switch selectable

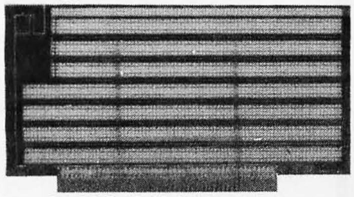
		List Price	Our Price
BTMURMM100	0 - 300 baud modem (2 lbs.)	$99.95	$79.00
BTCNDRS2328F	RS232 cable		$19.95

RETAIL STORE PHONE NUMBERS: (Chatsworth:) (213) 709-5464 - (IRVINE:) (714) 660-1411

PRIORITY ONE IS NUMBER 1!

PRIORITY ONE IS YOUR PROTOTYPING SUPER-MARKET

page PLUGBOARDS



S-100 PLUGBOARDS

PART NO.	DESCRIPTION	1-4	5-9	10-24
BTPGBP1001	S-100 Bare Board	$15.95	$13.95	$11.95
BTPGBP1002	S-100 Horizontal Busses	$22.95	$19.95	$17.95
BTPGBP1003	S-100 Vertical Busses	$22.95	$19.95	$17.95
BTPGBP1004	S-100 Pads Per Hole	$23.95	$20.95	$18.95

APPLE PLUGBOARDS

BTPGBP5001	Apple bare board	$15.95	$13.95	$11.95
BTPGBP5002	Apple horizontal busses	$22.95	$19.95	$18.95
BTPGBP5004	Apple pads per hole	$23.95	$20.95	$18.95

UNIVERSAL PLUGBOARDS

4.5" x 6.5" or 9.6" edge connector as indicated for .3", .4", .6", .9" dips. Accommodates .1" IDC connectors at top of board.

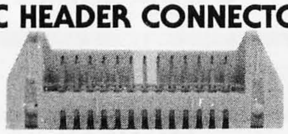
BTPGBP4411	4.5"x6" 22/44.156" bare board	$ 9.85	$ 8.95	$ 7.95
BTPGBP4413	4.5"x6" 22/44.156" 2 holes per pad vertical busses	$13.95	$12.50	$11.50
BTPGBP4414	4.5"x6" 22/44.156" pad per hole	$14.95	$13.50	$12.50
BTPGBP4421	4.5"x9.6" 22/44.156" bareboard	$10.95	$ 9.95	$ 8.95
BTPGBP4423	4.5"x9.6" 22/44.156" 2 holes per pad vertical busses	$14.95	$13.50	$12.50
BTPGBP4424	4.5"9.6" 22/44.156" pad per hole	$15.95	$14.50	$13.50
BTPGBP5611	4.5"x6" 28/56 .125 STD barebrd	$11.85	$10.95	$ 9.95
BTPGBP5613	4.5"x6" 28/56 .125 STD 2 holes per pad vertical busses	$15.95	$14.50	$13.50
BTPGBP5614	4.5"x6" 28/56 .125 STD pd/hole	$16.95	$15.50	$14.50
BTPGBP7211	4.5"x6" 36/72.1" bareboard	$ 9.85	$ 8.95	$ 7.95
BTPGBP7213	4.5"x6" 36/72.1" 2 holes per pad vertical busses	$13.95	$12.50	$11.50
BTPGBP7214	4.5"x6" 36/72.1" pad per hole	$14.95	$13.50	$12.50
BTPGBP7221	4.5"x9.6" 36/72.1" bareboard	$10.95	$ 9.95	$ 8.95
BTPGBP7223	4.5"x9.6" 36/72.1" 2 holes per pad vertical busses	$14.95	$13.50	$12.50
BTPGBP7224	4.5"x9.6" 36/72.1" pad per hole	$15.95	$14.50	$13.50

VECTOR IBM PC™ PLUGBOARDS

4.2" x 13.325" FR4 drilled & plated holes 31/62 contacts on .1 centers complete with card guide and mounting bracket that accepts "D" connectors.

PART NO.	DESCRIPTION	1-5	6-24	25+
BTVCT4613	IBM 3 holes per pad with horiz. busses f/soldering 44 16 pin dip capacity	$39.00	$35.10	$31.20
BTVCT4613-1	IBM bare board 84 16 pin dips	$26.95	$24.26	$21.56
BTVCT4613-2	IBM horizontal busses for wire wrap 55 16 pin dip capacity	$36.95	$33.26	$29.56

IDC HEADER CONNECTORS



RIGHT ANGLE SOLDERTAIL GOLD HEADER

.1" Spacing. Mounts on PC Board & Mates with IDC Socket above.

Part No.	NO. OF PINS	1-9	10-24	PRICE 25-99	100-249	250-999
BTIDCRAH10ST	5/10	1.20	1.10	1.00	.80	.65
BTIDCRAH20ST	10/20	1.90	1.60	1.20	1.00	.85
BTIDCRAH26ST	13/26	2.25	2.00	1.55	1.25	1.05
BTIDCRAH34ST	17/34	2.95	2.60	2.05	1.70	1.45
BTIDCRAH40ST	20/40	3.60	3.00	2.40	2.00	1.70
BTIDCRAH50ST	25/50	4.30	3.60	3.00	2.50	2.10

RIGHT ANGLE WIRE WRAP GOLD HEADER

BTIDCRAH10WW	5/10	2.60	2.35	2.10	1.80	1.50
BTIDCRAH20WW	10/20	4.00	3.50	2.75	2.20	1.80
BTIDCRAH26WW	13/26	5.00	4.30	3.50	2.90	2.40
BTIDCRAH34WW	17/34	5.95	5.00	4.15	3.20	2.70
BTIDCRAH40WW	20/40	7.00	6.00	4.90	4.00	3.40
BTIDCRAH50WW	25/50	7.95	6.50	5.90	5.00	4.00

CALL FOR STRAIGHT HEADERS NOT LISTED

TEXAS INSTRUMENTS

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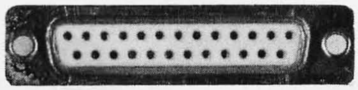
Qty	TIN BTTIS16LP
50 (Sh. Wt. 4 oz.)	$ 8.00
1000 (Sh. Wt. 4 lbs.)	$ 60.00
4500 (Sh. Wt. 15 lbs.)	$225.00

RS232 and "D" SUB-MINIATURE CONNECTORS



P=Plug, Male Type — S=Socket, Female Type

Part No.	No. Of Pins	1-9	PRICE 10-24	25-99	100-249	250-999	100+
BTCNDDE9P	9	$2.00	$1.60	$1.45	$1.35	$1.25	$1.05
BTCNDDE9S	9	$2.75	$2.40	$2.05	$1.85	$1.75	$1.60
BTCNDDA15P	15	$2.60	$2.30	$2.00	$1.80	$1.70	$1.55
BTCNDDA15S	15	$3.40	$3.00	$2.70	$2.50	$2.30	$2.15
BTCNDDB25P	25	$2.75	$2.50	$2.25	$1.95	$1.60	$1.35
BTCNDDB25S	25	$4.00	$3.50	$3.25	$3.00	$2.60	$2.25
BTCNDDC37P	37	$4.50	$4.00	$3.60	$3.30	$3.05	$2.80
BTCNDDC37S	37	$6.00	$5.40	$4.80	$4.30	$4.00	$3.70
BTCNDDD50P	50	$5.95	$5.35	$4.75	$4.25	$3.95	$3.60
BTCNDDD50S	50	$7.95	$7.20	$6.50	$6.00	$5.75	$5.50

"D" CONNECTOR HOODS

2 pc. Grey - Style A 2 pc Black - Style B 1 pc. Grey - Style C

Part No.	Pins/ Style	1-9	10-24	25-99	100-249	250-999	1000+
BTCNDDE9C	9A	$1.50	$1.25	$1.10	$1.00	$ .90	$ .80
BTCNDDA15C	15A	$1.50	$1.25	$1.10	$1.00	$ .90	$ .80
BTCNDP25H	25A	$1.50	$1.25	$1.10	$1.00	$ .90	$ .80
BTCNDDB51226	25B	$1.75	$1.50	$1.35	$1.20	$1.10	$ .95
BTCNDDB51212	25C	$1.65	$1.40	$1.25	$1.15	$1.05	$ .90
BTCNDDC37C	37A	$1.75	$1.50	$1.35	$1.20	$1.10	$ .95
BTCNDDD50C	50A	$2.00	$1.75	$1.50	$1.30	$1.15	$1.00
BTCNDD20418	Hrdware set 2/Pr	$1.00	$ .80	$ .70	$ .60	$ .50	$ .40

CENTRONICS/EPSON PRINTER CONNECTORS

BTCND5730360	Solder	$9.00	$7.50	$6.00	$5.25	$4.50
BTIDC5730360	IDC	$9.95	$9.00	$8.00	$7.00	$6.00

IDC INSULATION DISPLACEMENT D-SUBMINIATURE CONNECTORS

P=Plug, Male Type — S=Socket, Female Type — C=Cover Hood

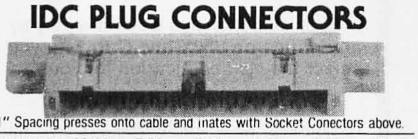
BTIDCDB25P	25	6.00	5.40	4.80	4.00	3.00
BTIDCDB25S	25	6.60	6.00	5.20	4.50	3.50
BTIDCDB25C	25	1.60	1.50	1.35	1.20	1.10

PLEASE CALL FOR IDC "D" CONNECTORS NOT LISTED

IDC SOCKET CONNECTORS

PART NO.	NO. OF PINS	1-9	10-24	PRICE 25-99	100-249	250-999
BTIDC10SKT	5/10	1.90	1.70	1.50	1.25	1.00
BTIDC20SKT	10/20	2.75	2.50	1.85	1.60	1.30
BTIDC26SKT	13/26	3.50	3.20	2.40	2.00	1.60
BTIDC34SKT	17/34	4.50	4.20	3.10	2.60	2.20
BTIDC40SKT	20/40	5.40	5.00	3.85	3.00	2.60
BTIDC50SKT	25/50	6.50	6.00	4.60	3.80	3.20

IDC PLUG CONNECTORS



.1" Spacing presses onto cable and mates with Socket Conectors above.

BTIDC682010	10/20	5.50	5.20	4.80	4.40	4.00
BTIDC682610	13/26	6.25	5.65	5.00	4.50	4.10
BTIDC683410	17/34	7.00	6.25	5.70	5.00	4.60
BTIDC684010	20/40	7.50	6.75	6.00	5.25	4.95
BTIDC685010	25/50	8.50	7.50	6.50	6.00	5.70

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BTRNS14TWW	14	30	.65	.55	.50	.47	.44
BTRNS16TWW	16	26	.75	.65	.52	.51	.46
BTRNS18TWW	18	23	.90	.79	.75	.70	.65
BTRNS20TWW	20	21	1.10	.95	.91	.87	.82
BTRNS22TWW	22	19	1.25	1.15	1.05	.94	.89
BTRNS24TWW	24	17	1.25	1.15	1.05	.96	.89
BTRNS28TWW	28	15	1.50	1.45	1.35	1.25	1.15
BTRNS40TWW	40	10	2.00	1.80	1.60	1.40	1.30

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PART NO.	PINS	STANDARD PKGE	EACH	10-49	50-99	100-499	500-999	1,000 +
BTRNS08LP	08	52	.25	N/A	.10	.08	.075	.07
BTRNS14LP	14	30	.25	.18	.15	.14	.12	.11
BTRNS16LP	16	26	.25	.20	.18	.16	.13	.12
BTRNS18LP	18	23	.30	.25	.22	.18	.15	.13
BTRNS20LP	20	21	.30	.25	.23	.20	.17	.145
BTRNS22LP	22	19	.35	.30	.25	.22	.19	.17
BTRNS24LP	24	17	.40	.35	.30	.24	.20	.18
BTRNS28LP	28	15	.45	.40	.35	.28	.24	.21
BTRNS40LP	40	10	.50	.45	.42	.40	.35	.31

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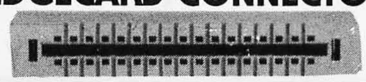

PART NO.	NO. OF PINS	1-9	10-24	PRICE 25-99	100-249	250-999
BTIDC10CE	5/10	3.95	3.55	3.00	2.50	2.00
BTIDC20CE	10/20	4.35	4.00	3.30	2.50	2.10
BTIDC26CE	13/26	5.00	4.25	3.50	2.70	2.30
BTIDC34CE	17/34	6.00	5.40	4.50	3.50	2.90
BTIDC40CE	20/40	6.80	6.20	5.30	4.20	3.40
BTIDC50CE	25/50	7.25	6.60	5.90	4.90	3.90

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PART NO.	NO. OF CONDUCTORS	PRICE PER SPOOL 10 Ft.	200 Ft*
BTIDC10CC*	10	$ 3.80	$ 60.00
BTIDC14CC*	14	4.75	80.00
BTIDC16CC*	16	5.50	90.00
BTIDC20CC*	20	7.00	120.00
BTIDC25CC*	25	8.50	150.00
BTIDC26CC*	26	8.50	150.00
BTIDC34CC*	34	11.00	195.00
BTIDC40CC*	40	13.00	230.00
BTIDC50CC*	50	16.00	280.00

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BTIDC10GY*	10	2.50	$36.00
BTIDC14GY*	14	3.50	50.00
BTIDC16GY*	16	4.00	60.00
BTIDC20GY*	20	4.80	75.00
BTIDC25GY*	25	6.00	95.00
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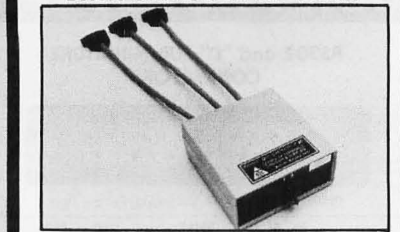

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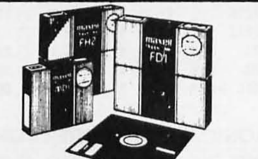

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12" x 13" SHEET	6.00

DISK CONTROLLERS

1771	11.95
1791	18.95
1793	18.95

CRT CONTROLLERS

DP8350	19.95
CRT5027	9.95
CRT5037	9.95

D-RAM CONTROLLERS

8202	17.95
8203	32.95
3242	5.95

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JDR Microdevices

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Circle 220 on inquiry card.

4164 64K DYNAMIC 200 NS $5.95

TMM2016 2KX8 STATIC 200 NS $4.15

STATIC RAMS

2101	256 x 4 (450ns)	1.95
5101	256 x 4 (450ns) (cmos)	3.95
2102-1	1024 x 1 (450ns)	.89
2102L-4	1024 x 1 (450ns) (LP)	.99
2102L-2	1024 x 1 (250ns) (LP)	1.49
2111	256 x 4 (450ns)	2.49
2112	256 x 4 (450ns)	2.99
2114	1024 x 4 (450ns)	8/9.95
2114-25	1024 x 4 (250ns)	8/10.95
2114L-4	1024 x 4 (450ns) (LP)	8/12.95
2114L-3	1024 x 4 (300ns) (LP)	8/13.45
2114L-2	1024 x 4 (200ns) (LP)	8/13.95
2147	4096 x 1 (55ns)	4.95
TMS4044-4	4096 x 1 (450ns)	3.49
TMS4044-3	4096 x 1 (300ns)	3.99
TMS4044-2	4096 x 1 (200ns)	4.49
MK4118	1024 x 8 (250ns)	9.95
TMM2016-200	2048 x 8 (200ns)	4.15
TMM2016-150	2048 x 8 (150ns)	4.95
TMM2016-100	2048 x 8 (100ns)	6.15
HM6116-4	2048 x 8 (200ns) (cmos)	4.75
HM6116-3	2048 x 8 (150ns) (cmos)	4.95
HM6116-2	2048 x 8 (120ns) (cmos)	8.95
HM6116LP-4	2048 x 8 (200ns) (cmos)(LP)	5.95
HM6116LP-3	2048 x 8 (150ns) (cmos)(LP)	6.95
HM6116LP-2	2048 x 8 (120ns) (cmos)(LP)	10.95
Z-6132	4096 x 8 (300ns) (Qstat)	34.95

LP = Low Power Qstat = Quasi-Static

DYNAMIC RAMS

TMS4027	4096 x 1 (250ns)	1.99
UPD411	4096 x 1 (300ns)	3.00
MM5280	4096 x 1 (300ns)	3.00
MK4108	8192 x 1 (200ns)	1.95
MM5298	8192 x 1 (250ns)	1.85
4116-300	16384 x 1 (300ns)	8/11.75
4116-250	16384 x 1 (250ns)	8/11.95
4116-200	16384 x 1 (200ns)	8/12.95
4116-150	16384 x 1 (150ns)	8/14.95
4116-120	16384 x 1 (120ns)	8/29.95
2118	16384 x 1 (150ns) (5v)	4.95
4164-200	65536 x 1 (200ns) (5v)	5.95
4164-150	65536 x 1 (150ns) (5v)	6.95

5V = single 5 volt supply

EPROMS

1702	256 x 8 (1us)	4.50
2708	1024 x 8 (450ns)	3.95
2758	1024 x 8 (450ns) (5v)	5.95
2716	2048 x 8 (450ns) (5v)	3.95
2716-1	2048 x 8 (350ns) (5v)	5.95
TMS2516	2048 x 8 (450ns) (5v)	5.50
TMS2716	2048 x 8 (450ns)	7.95
TMS2532	4096 x 8 (450ns) (5v)	5.95
2732	4096 x 8 (450ns) (5v)	4.95
2732-250	4096 x 8 (250ns) (5v)	8.95
2732-200	4096 x 8 (200ns) (5v)	11.95
2764	8192 x 8 (450ns) (5v)	9.95
2764-250	8192 x 8 (250ns) (5v)	14.95
2764-200	8192 x 8 (200ns) (5v)	24.95
TMS2564	8192 x 8 (450ns) (5v)	17.95
MC68764	8192 x 8 (450ns) (5v)(24 pin)	39.95
27128	16384x8 Call	Call

5v = Single 5 Volt Supply

EPROM ERASERS

	Timer	Capacity Chip	Intensity (uW/Cm²)	
PE-14		6	5,200	83.00
PE-14T	X	6	5,200	119.00
PE-24T	X	9	6,700	175.00
PL-265T	X	20	6,700	255.00
PR-125T	X	16	15,000	349.00
PR-320	X	32	15,000	595.00

Z-80

2.5 Mhz	
Z80-CPU	3.95
Z80-CTC	4.49
Z80-DART	10.95
Z80-DMA	14.95
Z80-PIO	4.49
Z80-SIO/0	16.95
Z80-SIO/1	16.95
Z80-SIO/2	16.95
Z80-SIO/9	16.95
4.0 Mhz	
Z80A-CPU	4.95
Z80A-CTC	4.95
Z80A-DART	11.95
Z80A-DMA	16.95
Z80A-PIO	4.95
Z80A-SIO/0	16.95
Z80A-SIO/1	16.95
Z80A-SIO/2	16.95
Z80A-SIO/9	16.95
6.0 Mhz	
Z80B-CPU	11.95
Z80B-CTC	13.95
Z80B-PIO	13.95
Z80B-DART	19.95
ZILOG	
Z6132	34.95
Z8671	39.95

CRYSTALS

32.768 khz	1.95
1.0 mhz	4.95
1.8432	4.95
2.0	3.95
2.097152	3.95
2.4576	3.95
3.2768	3.95
3.579535	3.95
4.0	3.95
5.0	3.95
5.0688	3.95
5.185	3.95
5.7143	3.95
6.0	3.95
6.144	3.95
6.5536	3.95
8.0	3.95
10.0	3.95
10.738635	3.95
14.31818	3.95
15.0	3.95
16.0	3.95
17.430	3.95
18.0	3.95
18.432	3.95
20.0	3.95
22.1184	3.95
32.0	3.95

CRT CONTROLLERS

6845	14.95
68B45	19.95
HD46505SP	15.95
6847	11.95
MC1372	6.95
68047	24.95
8275	29.95
7220	99.95
CRT5027	39.95
CRT5037	49.95
TMS9918A	39.95
DP8350	49.95

KEYBOARD CHIPS

AY5-2376	11.95
AY5-3600	11.95
AY5-3600 PRO	11.95

8000

8035	5.95
8039	6.95
INS-8060	17.95
INS-8073	24.95
8080	3.95
8085	5.95
8085A-2	11.95
8086	29.95
8087	CALL
8088	39.95
8089	89.95
8155	6.95
8155-2	7.95
8156	6.95
8185	29.95
8185-2	39.95
8741	39.95
8748	24.95
8755	24.95

8200

8202	24.95
8203	39.95
8205	3.50
8212	1.80
8214	3.85
8216	1.75
8224	2.25
8226	1.80
8228	3.49
8237	19.95
8237-5	21.95
8238	4.49
8243	4.45
8250	10.95
8251	4.49
8253	6.95
8253-5	7.95
8255	4.49
8255-5	5.25
8257	7.95
8257-5	8.95
8259	6.90
8259-5	7.50
8271	39.95
8272	39.95
8275	29.95
8279	8.95
8279-5	10.00
8282	6.50
8283	6.50
8284	5.50
8286	6.50
8287	6.50
8288	25.00
8289	49.95

DISC CONTROLLERS

1771	16.95
1791	24.95
1793	26.95
1795	49.95
1797	49.95
2791	54.95
2793	54.95
2795	59.95
2797	59.95
6843	34.95
8272	39.95
UPD765	39.95
MB8876	29.95
MB8877	34.95
1691	17.95
2143	18.95

CONNECTORS

RS232 MALE	2.50
RS232 FEMALE	3.25
RS232 HOOD	1.25
S-100 ST	3.95

6800

68000	59.95
6800	3.95
6802	7.95
6808	13.90
6809E	19.95
6809	11.95
6810	2.95
6820	4.35
6821	3.25
6828	14.95
6840	12.95
6843	34.95
6844	25.95
6845	14.95
6847	11.95
6850	3.25
6852	5.75
6860	9.95
6862	11.95
6875	6.95
6880	2.25
6883	22.95
68047	24.95
68488	19.95
6800 = 1MHZ	
68B00	10.95
68B02	22.25
68B09E	29.95
68B09	29.95
68B10	6.95
68B21	6.95
68B45	19.95
68B50	5.95
68B00 = 2 MHZ	

6500

1 MHZ	
6502	4.95
6504	6.95
6505	8.95
6507	9.95
6520	4.35
6522	7.95
6532	9.95
6545	22.50
6551	11.85
2 MHZ	
6502A	6.95
6522A	9.95
6532A	11.95
6545A	27.95
6551A	11.95
3 MHZ	
6502B	14.95

UARTS

AY3-1014	6.95
AY5-1013	3.95
AY3-1015	6.95
PT1472	9.95
TR1602	3.95
2350	9.95
2651	8.95
TMS6011	5.95
IM6402	7.95
IM6403	8.95
INS8250	10.95

GENERATORS

BIT-RATE	
MC14411	11.95
BR1941	11.95
4702	12.95
COM5016	16.95
COM8116	10.95
MM5307	10.95
FUNCTION	
MC4024	3.95
LM566	1.49
XR2206	3.75
8038	3.95

74LS00

74LS00	.24	74LS173	.69
74LS01	.25	74LS174	.55
74LS02	.25	74LS175	.55
74LS03	.25	74LS181	2.15
74LS04	.24	74LS189	8.95
74LS05	.25	74LS190	.89
74LS08	.28	74LS191	.89
74LS09	.29	74LS192	.79
74LS10	.25	74LS193	.79
74LS11	.35	74LS194	.69
74LS12	.35	74LS195	.69
74LS13	.45	74LS196	.79
74LS14	.59	74LS197	.79
74LS15	.35	74LS221	.89
74LS20	.25	74LS240	.95
74LS21	.29	74LS241	.99
74LS22	.25	74LS242	.99
74LS26	.29	74LS243	.99
74LS27	.29	74LS244	1.29
74LS28	.35	74LS245	1.49
74LS30	.25	74LS247	.75
74LS32	.29	74LS248	.99
74LS33	.55	74LS249	.99
74LS37	.35	74LS251	.59
74LS38	.35	74LS253	.59
74LS40	.25	74LS257	.59
74LS42	.49	74LS258	.59
74LS47	.75	74LS259	2.75
74LS48	.75	74LS260	.59
74LS49	.75	74LS266	.55
74LS51	.25	74LS273	1.49
74LS54	.29	74LS275	3.35
74LS55	.29	74LS279	.49
74LS63	1.25	74LS280	1.98
74LS73	.39	74LS283	.69
74LS74	.35	74LS290	.89
74LS75	.39	74LS293	.89
74LS76	.39	74LS295	.99
74LS78	.49	74LS298	.89
74LS83	.60	74LS299	1.75
74LS85	.69	74LS323	3.50
74LS86	.39	74LS324	1.75
74LS90	.55	74LS352	1.29
74LS91	.89	74LS353	1.29
74LS92	.55	74LS363	1.35
74LS93	.55	74LS364	1.95
74LS95	.75	74LS365	.49
74LS96	.89	74LS366	.49
74LS107	.39	74LS367	.45
74LS109	.39	74LS368	.45
74LS112	.39	74LS373	1.39
74LS113	.39	74LS374	1.39
74LS114	.39	74LS377	1.39
74LS122	.45	74LS378	1.18
74LS123	.79	74LS379	1.35
74LS124	2.90	74LS385	1.90
74LS125	.49	74LS386	.45
74LS126	.49	74LS390	1.19
74LS132	.59	74LS393	1.19
74LS133	.59	74LS395	1.19
74LS136	.39	74LS399	1.49
74LS137	.99	74LS424	2.95
74LS138	.55	74LS447	.37
74LS139	.55	74LS490	1.95
74LS145	1.20	74LS624	3.99
74LS147	2.49	74LS640	2.20
74LS148	1.35	74LS645	2.20
74LS151	.55	74LS668	1.69
74LS153	.55	74LS669	1.89
74LS154	1.90	74LS670	1.49
74LS155	.69	74LS674	9.65
74LS156	.69	74LS682	3.20
74LS157	.65	74LS683	3.20
74LS158	.59	74LS684	3.20
74LS160	.69	74LS685	3.20
74LS161	.65	74LS688	2.40
74LS162	.69	74LS689	3.20
74LS163	.65	74LS783	24.95
74LS164	.69	81LS95	1.49
74LS165	.95	81LS96	1.49
74LS166	1.95	81LS97	1.49
74LS168	1.75	81LS98	1.49
74LS169	1.75	25LS2521	2.80
74LS170	1.49	25LS2569	4.25

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Circle 221 on inquiry card.

2114 450 NS 8/$9.95   2114 250 NS 8/$10.95

7400

7400	.19	74132	.45
7401	.19	74136	.50
7402	.19	74141	.65
7403	.19	74142	2.95
7404	.19	74143	2.95
7405	.25	74145	.60
7406	.29	74147	1.75
7407	.29	74148	1.20
7408	.24	74150	1.35
7409	.19	74151	.55
7410	.19	74152	.65
7411	.25	74153	.55
7412	.30	74154	1.25
7413	.35	74155	.75
7414	.49	74156	.65
7416	.25	74157	.55
7417	.25	74159	1.65
7420	.19	74160	.85
7421	.35	74161	.69
7422	.35	74162	.85
7423	.29	74163	.69
7425	.29	74164	.85
7426	.29	74165	.85
7427	.29	74166	1.00
7428	.45	74167	2.95
7430	.19	74170	1.65
7432	.29	74172	5.95
7433	.45	74173	.75
7437	.29	74174	.89
7438	.29	74175	.89
7440	.19	74176	.89
7442	.49	74177	.75
7443	.65	74178	1.15
7444	.69	74179	1.75
7445	.69	74180	.75
7446	.69	74181	2.25
7447	.69	74182	.75
7448	.69	74184	2.00
7450	.19	74185	2.00
7451	.23	74190	1.15
7453	.23	74191	1.15
7454	.23	74192	.79
7460	.23	74193	.79
7470	.35	74194	.85
7472	.29	74195	.85
7473	.34	74196	.79
7474	.33	74197	.75
7475	.45	74198	1.35
7476	.35	74199	1.35
7480	.59	74221	1.35
7481	1.10	74246	1.35
7482	.95	74247	1.25
7483	.50	74248	1.85
7485	.59	74249	1.95
7486	.35	74251	.75
7489	2.15	74259	2.25
7490	.35	74265	1.35
7491	.40	74273	1.95
7492	.50	74276	1.25
7493	.35	74279	.75
7494	.65	74283	2.00
7495	.55	74284	3.75
7496	.70	74285	3.75
7497	2.75	74290	.95
74100	1.75	74293	.75
74107	.30	74298	.85
74109	.45	74351	2.25
74110	.45	74365	.65
74111	.55	74366	.65
74116	1.55	74367	.65
74120	1.20	74368	.65
74121	.29	74376	2.20
74122	.45	74390	1.75
74123	.49	74393	1.35
74125	.45	74425	3.15
74126	.45	74426	.85
74128	.55	74490	2.55

LINEAR

LM301	.34	LM340 (see 7800)		LM566	1.49	LM1800	2.37
LM301H	.79	LM348	.99	LM567	.89	LM1812	8.25
LM307	.45	LM350K	4.95	NE570	3.95	LM1830	3.50
LM308	.69	LM350T	4.60	NE571	2.95	LM1871	5.49
LM308H	1.15	LM358	.69	NE592	2.75	LM1872	5.49
LM309H	1.95	LM359	1.79	LM709	.59	LM1877	3.25
LM309K	1.25	LM376	3.75	LM710	.75	LM1889	1.95
LM310	1.75	LM377	1.95	LM711	.79	LM1896	1.75
LM311	.64	LM378	2.50	LM723	.49	ULN2003	2.49
LM311H	.89	LM379	4.50	LM723H	.55	LM2877	2.05
LM312H	1.75	LM380	.89	LM733	.98	LM2878	2.25
LM317K	3.95	LM380N-8	1.10	LM741	.35	LM2900	.85
LM317T	1.19	LM381	1.60	LM741N-14	.35	LM2901	1.00
LM318	1.49	LM382	1.60	LM741H	.40	LM3900	.59
LM318H	1.59	LM383	1.95	LM747	.69	LM3905	1.25
LM319H	1.90	LM384	1.95	LM748	.59	LM3909	.98
LM319	1.25	LM386	.89	LM1014	1.19	LM3911	2.25
LM320 (see 7900)		LM387	1.40	LM1303	1.95	LM3914	3.95
LM322	1.65	LM389	1.35	LM1310	1.49	LM3915	3.95
LM323K	4.95	LM390	1.95	MC1330	1.69	LM3916	3.95
LM324	.59	LM392	.69	MC1349	1.89	MC4024	3.95
LM329	.65	LM394H	4.60	MC1350	1.19	MC4044	4.50
LM331	3.95	LM399H	5.00	MC1358	1.69	RC4136	1.25
LM334	1.19	NE531	2.95	MC1372	6.95	RC4151	3.95
LM335	1.40	NE555	.34	LM1414	1.59	LM4250	1.75
LM336	1.75	NE556	.65	LM1458	.59	LM4500	3.25
LM337K	3.95	NE558	1.50	LM1488	.69	RC4558	.69
LM337T	1.95	NE561	24.95	LM1489	.69	LM13080	1.29
LM338K	6.95	NE564	2.95	LM1496	.85	LM13600	1.49
LM339	.99	LM565	.99	LM1558H	3.10	LM13700	1.49

H = TO-5 CAN   T = TO-220   K = TO-3

RCA

CA 3023	2.75	CA 3082	1.65
CA 3039	1.29	CA 3083	1.55
CA 3046	1.25	CA 3086	.80
CA 3059	2.90	CA 3089	2.99
CA 3060	2.90	CA 3096	3.49
CA 3065	1.75	CA 3130	1.30
CA 3080	1.10	CA 3140	1.15
CA 3081	1.65	CA 3146	1.85
CA 3160	1.19		

TI

TL494	4.20	75365	1.95
TL496	1.65	75450	.59
TL497	3.25	75451	.39
75107	1.49	75452	.39
75110	1.95	75453	.39
75150	1.95	75454	.39
75154	1.95	75491	.79
75188	1.25	75492	.79
75189	1.25	75493	.89
75494	.89		

BI FET

TL071	.79	TL084	2.19
TL072	1.19	LF347	2.19
TL074	2.19	LF351	.60
TL081	.79	LF353	1.00
TL082	1.19	LF355	1.10
TL083	1.19	LF356	1.10
LF357	1.40		

CMOS

4000	.29	4527	1.95
4001	.25	4528	1.19
4002	.25	4531	.95
4006	.89	4532	1.95
4007	.29	4538	1.95
4008	.95	4539	1.95
4009	.39	4541	2.64
4010	.45	4543	1.19
4011	.25	4553	5.79
4012	.25	4555	.95
4013	.38	4556	.95
4014	.79	4581	1.95
4015	.39	4582	1.95
4016	.39	4584	.75
4017	.69	4585	.75
4018	.79	4702	12.95
4019	.39	74C00	.35
4020	.75	74C02	.35
4021	.79	74C04	.35
4022	.79	74C08	.35
4023	.29	74C10	.35
4024	.65	74C14	.59
4025	.29	74C20	.35
4026	1.65	74C30	.35
4027	.45	74C32	.39
4028	.69	74C42	1.29
4029	.79	74C48	1.99
4030	.39	74C73	.65
4034	1.95	74C74	.65
4035	.85	74C76	.80
4040	.75	74C83	1.95
4041	.75	74C85	1.95
4042	.69	74C86	.39
4043	.85	74C89	4.50
4044	.79	74C90	1.19
4046	.85	74C93	1.75
4047	.95	74C95	.99
4049	.35	74C107	.89
4050	.35	74C150	5.75
4051	.79	74C151	2.25
4053	.79	74C154	3.25
4060	.89	74C157	1.75
4066	.39	74C160	1.19
4068	.39	74C161	1.19
4069	.29	74C162	1.19
4070	.35	74C163	1.19
4071	.29	74C164	1.39
4072	.29	74C165	2.00
4073	.29	74C173	.79
4075	.29	74C174	1.19
4076	.79	74C175	1.19
4078	.29	74C192	1.49
4081	.29	74C193	1.49
4082	.29	74C195	1.39
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4093	.49	74C373	2.45
4098	2.49	74C374	2.45
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14411	11.95	74C905	10.95
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74S04	.35	74S174	.95
74S05	.35	74S175	.95
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7815T	.75	7924T	.85
7824T	.75		
7805K	1.39	7905K	1.49
7812K	1.39	7912K	1.49
7815K	1.39	7915K	1.49
7824K	1.39	7924K	1.49
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78L12	.69	79L12	.79
78L15	.69	79L15	.79
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C, T = TO-220   K = TO-3
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PROMS

Order by National Part	Function	TI	SIG	MIMI	Harris	
		EQUIVALENT PART NUMBERS				
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74S287	256x4 TS	24S10	82S129	6301-1	7611	1.90
74S288	32x8 TC	18S030	82S123	6331-1	7603	1.90
74S387	256x4 OC	24SA10	82S126	6300-1	7610	1.95
74S471	256x8 TS	28L22		6309-1		4.95
74S472	512x8 TS	28S42	82S147	6349-1	7649	4.95
74S473	512x8 OC	28SA42	82S146	6348	7648	10.95
74S474	512x8 TS	28S46	82S141	6341	7641	4.95
74S475	512x8 TS	28SA46	82S140	6340	7640	12.95
74S478	1Kx8 TS	28S86				19.95
74S570	512x4 OC	27S12	82S130	6305	7620	2.95
74S571	512x4 TS	27S13	82S131	6306-1	7621	2.95
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74S573	1kx4 TS	24S41	82S137	6353-1	7643	9.95
87S180	1kx8 OC	28SA86	82S180	6380-1	7680	19.25
87S181	1kx8 TS	28L86	82S181	6381-1	7681	16.25
87S184	2kx4 OC	24SA81	82S184		7684	17.20
87S185	2kx4 TS	24S81	82S185		7685	16.95
87S190	2kx4 OC	28SA166	82S190		76160	39.95
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	6V	10V	15V	20V	25V	35V	50V
.22uf						.40	
.27						.40	
.33						.40	.45
.47				.35			.50
.68						.45	.50
1.0			.40	.40	.45	.45	
1.5				.45		.50	.60
1.8							.75
2.2		.35	.40	.45		.65	.85
2.7		.40	.45				.90
3.3		.45	.50	.55	.60	.65	.90
3.9		.45					
4.7	.45	.55		.60	.65	.85	.90
6.8			.70		.75		
8.2							1.00
10	.55	.65	.80	.85	.90	1.00	
12	.65		.85	.90			
15	.75	.85	.90				
18			1.25				
22		1.00	1.35				
27			2.25				
39		1.50					
47	1.35						
56	1.75						
100		3.25					
270	3.75						

DISC

10pf	50V	.05	470	50V	.05
22	50V	.05	560	50V	.05
25	50V	.05	680	50V	.05
27	50V	.05	820	50V	.05
33	50V	.05	.001uf	50V	.05
47	50V	.05	.0015	50V	.05
56	50V	.05	.0022	50V	.05
68	50V	.05	.005	50V	.05
82	50V	.05	.01	50V	.07
100	50V	.05	.02	50V	.07
220	50V	.05	.05	50V	.07
330	50V	.05	.1	12V	.10
			.1	50V	.12

MONOLITHIC

.1uf-mono 50V .18   .47uf-mono 50V .25

ELECTROLYTIC

RADIAL			AXIAL		
.47uf	50V	.14	1uf	50V	.14
1	25V	.14	4.7	16V	.14
2.2	35V	.15	10	16V	.14
4.7	50V	.15	10	50V	.16
10	50V	.15	22	16V	.14
47	35V	.18	47	50V	.20
100	16V	.18	100	15V	.20
220	35V	.20	100	35V	.25
470	25V	.30	150	25V	.25
2200	16V	.60	220	25V	.30
			330	16V	.40
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4N35	1.25	ILQ-74	2.75
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18 pin ST	.20	.18
20 pin ST	.29	.27
22 pin ST	.30	.27
24 pin ST	.30	.27
28 pin ST	.40	.32
40 pin ST	.49	.39
64 pin ST	4.25	call
ST = SOLDERTAIL		
8 pin WW	.59	.49
14 pin WW	.69	.52
16 pin WW	.69	.58
18 pin WW	.99	.90
20 pin WW	1.09	.98
22 pin WW	1.39	1.28
24 pin WW	1.49	1.35
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WW = WIREWRAP		
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KBP04	400PIV 1.5amp bridge	.55
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2N918	.50	MPS3706	.15
MPS918	.25	2N3772	1.85
2N2102	.75	2N3903	.25
2N2218	.50	2N3904	.10
2N2218A	.50	2N3906	.10
2N2219	.50	2N4122	.25
2N2219A	.50	2N4123	.25
2N2222	.25	2N4249	.25
PN2222	.10	2N4304	.75
MPS2369	.25	2N4401	.25
2N2484	.25	2N4402	.25
2N2905	.50	2N4403	.25
2N2907	.25	2N4857	1.00
PN2907	.125	PN4916	.25
2N3055	.79	2N5086	.25
3055T	.69	PN5129	.25
2N3393	.30	PN5139	.25
2N3414	.25	2N5209	.25
2N3563	.40	2N6028	.35
2N3565	.40	2N6043	1.75
PN3565	.25	2N6045	1.75
MPS3638	.25	MPS-A05	.25
MPS3640	.25	MPS-A06	.25
PN3643	.25	MPS-A55	.25
PN3644	.25	TIP29	.65
MPS3704	.15	TIP31	.75
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DESCRIPTION	HIGH RELIABILITY TOOLED ST IC SOCKETS	COMPONENT CARRIERS (DIP HEADERS)	RIBBON CABLE DIP PLUGS (IDC)
ORDER BY	AUGATxx-ST	ICCxx	IDPxx
CONTACTS 8	.99	.65	
14	.99	.75	1.45
16	.99	.85	1.65
18	1.69	1.00	
20	1.89	1.25	
22	1.89	1.25	
24	1.99	1.35	2.50
28	2.49	1.50	
40	2.99	2.10	4.15

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±12 VOLT 1 AMP

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20	.65	5.70	1.25	11.00
25	.75	6.60	1.32	11.60
26	.75	6.60	1.32	11.60
34	.98	8.60	1.65	14.50
40	1.32	11.60	1.92	16.80
50	1.38	12.10	2.50	22.00

D-SUBMINIATURE

DESCRIPTION	SOLDER CUP MALE	SOLDER CUP FEMALE	RIGHT ANGLE PC SOLDER MALE	RIGHT ANGLE PC SOLDER FEMALE	IDC RIBBON CABLE MALE	IDC RIBBON CABLE FEMALE	HOODS BLACK	HOODS GREY
ORDER BY	DBxxP	DBxxS	DBxxPR	DBxxSR	IDBxxP	IDBxxS	HOOD-B	HOOD
CONTACTS 9	2.08	2.66	1.65	2.18	3.37	3.69	---	1.60
15	2.69	3.63	2.20	3.03	4.70	5.13	---	1.60
25	2.50	3.25	3.00	4.42	6.23	6.84	1.25	1.25
37	4.80	7.11	4.83	6.19	9.22	10.08	---	2.95
50	6.06	9.24	---	---	---	---	---	3.50

For order instructions see "IDC Connectors" below.

CALL FOR MOUNTING HARDWARE

IDC CONNECTORS

DESCRIPTION	SOLDER HEADER	RIGHT ANGLE SOLDER HEADER	WW HEADER	RIGHT ANGLE WW HEADER	RIBBON HEADER SOCKET	RIBBON HEADER	RIBBON EDGE CARD
ORDER BY	IDHxxS	IDHxxSR	IDHxxW	IDHxxWR	IDSxx	IDMxx	IDExx
CONTACTS 10	.82	.85	1.86	2.05	1.15	---	2.25
20	1.29	1.35	2.98	3.28	1.86	5.50	2.36
26	1.68	1.76	3.84	4.22	2.43	6.25	2.65
34	2.20	2.31	4.50	4.45	3.15	7.00	3.25
40	2.58	2.72	5.28	4.80	3.73	7.50	3.80
50	3.24	3.39	6.63	7.30	4.65	8.50	4.74

ORDERING INSTRUCTIONS: Insert the number of contacts in the position marked "**xx**" of the "order by" part number listed. **Example:** A 10 pin right angle solder style header would be IDH**10**SR.

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Unclassified Ads

WANTED: Nonprofit organization of volunteer professionals devoted to rehabilitation research and community service for persons with hearing or vision impairments needs microcomputer system suitable for limited word processing and telecommunications applications, several modems, two terminals, and at least one fast printer. Donations are fully tax-exempt. J. Whitlock, New England Institute of Applied Biophysics, 59 North Ashland St., Worcester, MA 01609, (617) 798-8707.

WANTED: The Vietnam Veterans' Resocialization Program is seeking a tax-deductible donation of an Apple II Plus with two disk drives. Our veterans' self-help organization needs to computerize the database, implement word processing, and upgrade the accounting and budget processes. Our references and IRS information on request. Bill Kittredge, Vietnam Veterans' Resocialization Program, Box 1319, Springfield, OR 97477, (503) 687-6918.

WANTED: Health service group is seeking a tax-deductible donation of a TRS-80 Model I or III hardware and software. Thomas G. Lareau, Edgar Area Medical Center, 107 3rd Ave., Edgar, WI 54426, (715) 352-2302.

WANTED: Nonprofit early childhood program, interested in exposing the children to a tool of the present and future, is seeking an Apple computer. Sharon Swain, Childhood Development Center, 1229 West 2nd, McMinnville, OR 97128, (503) 472-1009.

WANTED: Nonprofit community organization seeks tax-deductible personal computer for community programs such as research, record keeping (for food co-op), tutoring, Neighborhood Watch, fund raising, and grassroots organizing. Brad Fields, Citizens Action Research Project, 730 East 7th St., National City, CA 92050, (619) 474-8569.

WANTED: Minicomputer system for nonprofit organization. Any donation would be fully tax-deductible. Roy Tanenbaum, 160 Westwood Dr., Park Forest, IL 60466, (312) 747-9513.

WANTED: Tax-deductible donation of a ZX-81-compatible computer for Boy Scouts of America, Order of the Arrow organization. We need it to keep financial records and mailing lists of members. Will send receipt and pay shipping costs. Also, same needed for a computer science student in high school. Roger Hull, Rt. 4, Box 120, Marlow, OK 73055, (405) 658-5175 after 4 p.m. CT.

WANTED: Portuguese graduate student with experience in 2D and 3D CAD, IBM, CDC, PRIME, and FORTRAN seeks working holidays in the U.S. during summer '83. Will bring my Sinclair Spectrum with 80K, drive, FORTH, PASCAL, BASIC Compiler, and Z80 ASS/DIS. My interest is in music projects. Tony Pereira, Amsterdamse Veerkade-41 F, 2512 AH The Hague, Holland.

WANTED: I need a copy of Douglas Maurer's two-part article: Processing Algebraic Expressions, Parts 1 and 2. The articles appeared consecutively in BYTE February and March 1976. I'll pay costs. Ronald Malpeli, 142-02 Franklin Ave., Flushing, NY 11355, (212) 762-2249.

WANTED: Apple II users who are interested in communicating about Assembler programs and/or trying to change existing ones. Armin Herold, Bahnwaldstr. 21/I, 7910 Neu-Ulm 8, West Germany.

FOR SALE: Texas Instruments Silent 745 used terminals at less than half price. Russell White, (212) 997-6075.

WANTED: Accountant seeks communication with user groups in the Great Lakes area for the TRS-80 Model II business computer. Michael Gouthro, Complete Bookkeeping Service, Box 8130, Dundas, Ontario L9H 5E7, Canada.

FOR SALE: KGS-80 and cables for Apple and TRS-80 Model I. Adapts your Selectric to work as a letter-quality printer. Original cost $595. Like-new condition: $300. R. Markman, 638 Meadow Court, Westbury, NY 11590.

FOR SALE: TRS-80 Model I with Level II BASIC and 16K RAM, Editor/Assembler and Debug along with assorted programs, manuals, and graphics texts: best offer. Also, brand new Line Printer VII with parallel-port cable, paper, and manuals: $400. Mark Marine, 4717 Mermaid Blvd., Wilmington, DE 19808, (302) 239-0905.

FOR SALE: 128K Apple III with green screen monitor, external disk drive, and MX-80 printer with Graftrax-80. Software includes Apple Business BASIC, Apple III Visicalc, Apple II Emulation, and many utilities. About six months old; perfect condition: $3900. Randy Murrish, 2919 Ave. E, Kearney, NE 68847.

FOR SALE: New Intel 86/12A single-board computer. System includes 8086 processor, system clock, 32K bytes of dual-port RAM, Multibus arbitration logic, vectored interrupt controller, two programmable timers, 24 programmable I/O lines, and a USART. Lists at $1950, will sell for $700. F.J. Posivak, 68 Hickory Dr., Quakertown, PA 18951, (215) 536-7587.

FOR SALE: TRS-80 Model I with 48K includes processor with lowercase adapater, expansion interface, one disk drive, monitor, and over $800 in software. Excellent condition. Software includes word processors, business programs, utilities, and games. Asking $1200 or will trade for a TRS-80 Color Computer with monitor, disk drive, and Flex DOS. Will Carter, 4407 Griffin St., Moss Point, MS 39563, (601) 475-6855.

WANTED: Apple software to swap. Will trade a large library of programs for anything from utilities to arcade games. Send a list of your programs and I will send you mine. Please include a SASE. Gary Derksen, 926 20 A Ave., Coaldale, Alberta T0K 0L0, Canada, (403) 345-4697.

WANTED: Computer listings for TRS-80 Model I Level II 16K RAM or Apple II Plus 3.3 DOS. Any type of program will do: games, graphics, or personal. I will send a list of same in return. Matt Jenkins, 220 Westwood Dr., Thompson, Manitoba R8N 0E9, Canada.

NEEDED: I am interested in corresponding with Morrow Micro-Decision users, groups, clubs, or newsletters. Also, will pay for schematics for this machine. Stan Ahalt, 102-B Victoria Lane, Clemson, SC 29631, (803) 656-3376, 654-2748 evenings.

FOR SALE: Trendcom 200 (Apple Silentype) thermal printer. Recent factory overhaul. With several rolls of paper, no cable or interface. Send SASE for sample output. $295 delivered anywhere in continental USA. M. Weiss, 7656 Daniel Dr., New Orleans, LA 70127.

FOR SALE: Radio Shack Line Printer VII, a few months old, perfect condition, high-density graphic, prints 40 or 80 uppercase and lowercase, uses standard fanfold paper, and parallel and serial interfaces: $275 or best offer. Peter Lee, 100 LaSalle Court, New Orleans, LA 70118, (504) 865-2447 after 5 p.m.

WANTED: A Timex/Sinclair user group would like to hear from other owners or user groups willing to trade or swap software and information. Send 50¢ (stamps ok) and SASE for details. North Bay Computing, 500 Eastwood Dr., Petaluma, CA 94952.

FOR SALE: Cipher Microstreamer tape drive, ½-inch, 1600-bpi, PE format. Uses standard IBM-compatible reel-type magnetic tapes. Alloy Engineering intelligent tape-drive controller board for S-100 bus. Software utilities which operate under CP/M 2.2+ or MP/M 1.1+. New condition: $4400 or best offer. R. Luebbe, POB 6206, Falls Church, VA 22046, (703) 573-3849.

FOR SALE: Assembled S-100 board with documentation: SSM Music Synthesizer (MUS-X1): $150. SSM Video Interface (VB1B): $100. Two SSM 8K static RAM (MB6A): $50 each. SSM 8080 processor board with 2K EPROM monitor: $100. Ithaca Audio 8K static RAM: $50. 10-slot motherboard with power supply, card cage, and chassis (without cover): $110. 22-slot motherboard with chassis (without cover): $100. David Gee, 1624-70th Ave., Oakland, CA 94621, (415) 562-5098.

FOR SALE: 13-inch color monitor: $269. Computer interface for VIC-20 or 64 to a video cassette recorder to store 50 megabytes per tape: $99. Dennis Hallingstad, 318 S. K., Sparta, WI 54656.

FOR SALE: Heath H-14 printer with manuals: $250. GE TN-300 printer with RS-232C interface: $100. Hazeltine/GE TN-1200 printer with parallel interface: $200. James Schnitzmeyer, 606 South Main, Box 64, Albany, IL 61230, (309) 887-5106.

FOR SALE: Grappler+ interface card, new, unused, and tested. Has parallel interface cable, connectors, instruction book, and warranty; in original package: $99. Larry Solomon, 5122 North Tortolita Rd., Tucson, AZ 85745, (602) 743-7924.

FOR SALE: Compuprism S-100 color-graphics board. 144h by 192v pixel plane with each pixel independently programmed in eight colors. Assembled from bare board, runs just fine; selling due to incompatibility with my memory board. Also, I want a Microangelo graphics board MA520. David Bodette, 202 Nuclear Science Center, Gainesville, FL 32611, (904) 392-3880 or 378-4313.

FOR SALE: IMSAI 8080A with 48K RAM, video board, 4 parallel I/O ports, single drive, keyboard, North Star DOS, several disks. All in working order: $375 FOB here. Harry Mayer, 10 Woodmere, Skaneateles, NY 13152, (315) 685-3310.

FOR TRADE: Want to swap programs for Apple II Plus or Franklin 1000 computer. Send your list of programs or games and I'll send mine. Marv Alpert, 4 Harwood Dr. W, Glen Cove, NY 11542.

FOR SALE: Cromemco Z-2D, 64K RAM memory (four 16K), dual Wanco drives, Beehive B100 terminal, Centronics 703 printer with VFU, and software. All for $4500. A. Smart, 2036 Colony St. #7, Mountain View, CA 94043, (415) 968-0159.

FOR SALE: Mountain computer 100,000 day clock for S-100 bus. 100ms minimum interval. Battery backup. Unused: $125. D. Russell, 12 Winchester, Southboro, MA 01772, (617) 485-7516.

FOR SALE: DS-65 Video Digitizer for the Apple II. Sells new for around $650; will sell for $500 or best offer. Will also consider trade for text-to-speech synthesizer with programmable pitch and inflection. Brian Prigge, 523 Wilson Ave. SE, St. Cloud, MN 56301, (612) 252-1615.

FOR SALE: Commodore VIC-20 computer with data cassette recorder. Will also include Super Expander and two cartridge games (Gorf and Radar Rat Race). Will accept all reasonable offers. Both manuals included. Enrico Vaccaro, 716 East 81 St., Brooklyn, NY 11236.

WANTED: Low-cost ($5 to $75) new or used microcomputers (VIC-20, TI-99/2/4, AIM-65, Venture, etc.) or memory devices (cheap disk drive, stringy floppy, memory-expansion modules for TI-99/2/4, VIC-20, Timex 1000, Sinclair ZX81, etc.) for my experiments with videodisc players and optical bar-code reader wands. David Lyons, 1118 South Clinton #M, Oak Park, IL 60304.

FOR SALE: Epson Graftrax 80 graphics ROMs set, bit-plot graphics capability for Epson MX-80 printers, includes original manual: $35. Also, Radio Shack TRS-80 Model I, Level II BASIC, 48K memory with lowercase modification: $800. Kenneth Hom, 13B Magnolia Lane, Eatontown, NJ 07724, (201) 542-1500 ext. 292.

FOR SALE: Enhance your Apple II with Apple IIe features: lowercase, auto-repeat keys, and more. Videx Keyboard Enhancer II: $99 (retail $149). Videx Videoterm Board: $199 (retail $345), offers 80-column display. Videx Soft Video Switch: $19 (retail $35). 16K RAM Board: $49 (retail $195). Excellent condition. Original cartons and documentation. Bob Britton, 6111 Jadecrest Court, Spring, TX 77379, (713) 376-7525.

WANTED: Apple users who want to start a software user's group. Interested persons may send me your disk of copyable material to copy. I will then send your disk back with programs I have acquired from other users (specify interest). Brett Combs, POB 447, Whitesboro, TX 76273.

FOR SALE: Diablo 1640 KSR (keyboard send/receive) letter-quality, daisy-wheel printing terminals with serial RS-232C interface. Can double as a printer or as a stand-alone terminal. Little use; like-new condition: $2000 or best offer. Robert Thompson, 214 Basket Rd., Webster, NY 14580, (716) 265-0384.

FOR SALE: Lear-Siegler ADM-42 terminal with 16 function keys, printer port, expanded memory (8 pages). Also, Ven-Tel 212 modem, 300 or 1200 data rate with auto-answer and self-test features. Prices negotiable. Mike Gage, (703) 978-1763.

FOR SALE: SYM-1 single-board microcomputer, fully assembled with 28-key dual-function keyboard, 6-digit LED display, 1K RAM expandable on board to 4K, cassette interface, single +5 volt operation, and 6502 microprocessor. $100 or best offer. Jeff Taragin, (301) 628-8516 days, 764-6091 evenings.

FOR SALE: North Star time-shared multiuser computer system (less terminals and printers), four user 288K plus memory 18-megabye hard disk. Two double-density double-sided floppy disks. High-performance, low-cost system: $6000. R. Morrison, POB 188, Cannon Beach, OR 97110, (503) 436-1122.

FOR SALE: TRS-80 Model I, Level II BASIC, 32K RAM. Accessories include disk drive, video monitor, expansion interface, home controller, cassette recorder, and line printer IV with proportional spacing. Also, Scriptsit word processing, mailing list, Tiny Pascal, Editor/Assembler, and tons of other software packages. All manuals and documentation. $1500 or best offer. Cliff Brust, 408 West David Rd., Kettering, OH 45429, (513) 667-2431 ext. 2243.

WANTED: Will pay $7 for an unused set of keyboard command stickers (overlays) as originally issued with the Programma Apple PIE word-processor program. Check sent immediately on receipt. Robert Greenwald, POB 401, Wheatley Heights, NY 11798.

FOR SALE: SwTPC 6800 with 4K memory, PERCOM cassette/terminal interface and full documentation: $150 or best offer. Julius Cassels, RFD 1, Suncook, NH 03275, (603) 736-8179.

WANTED: Used circuit boards from similar models for a ComData Model 933 teletypewriter/plotter terminal. H. E. Fiehler, 4200 East University, Middletown, OH 45042.

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Unclassified Ads

FOR SALE: Hazeltine Esprit terminal. Perfect condition, no longer needed due to recent computer acquisition: $500. Also, would like to correspond with Micropolis DOS users, preferably Model II users. Gunnar Seaburg, URH 119 Townsend, 1010 West Illinois, Urbana, IL 61801.

FOR SALE: S-100 Z80 CP/M system, 64K high-speed static memory, 128K electronic disk (semidisk), two double-sided double-density 8-inch disk drives (2.4 megabytes), two serial ports, two parallel ports, CP/M 2.2. Also, word processing, communication, C, and Pascal software. Manuals and disks. A year old; $1995. Richard Schwartz, 454 26th Ave., San Mateo, CA 94403, (415) 859-5875.

FOR SALE: Ohio Scientific C4P-DF, color video system-DAC, output. 48K RAM 8-inch dual, floppy disks, two joysticks, 1982 factory update. DOS 3.3 manuals, little used. Cost $3200; will sell for $2400 or best offer. Robert M. Woldman, 2120 St. Clair Ave., Cleveland, OH 44114, (216) 241-2267.

FOR SALE: Heath H-19 terminal, H-11A computer with 32K memory, two serial one parallel interface cards, 300-bps direct-connect modem, and manuals. Excellent condition: $1200. M.D. Erdman, 2211 Thornhill Rd., Tifton, GA 31794, (912) 382-9498.

FOR SALE: MSI 6800 computer system. 32K, two serial I/O ports, FD-8 dual 8-inch disk drives, TI-810 printer, LSI ADM-3A terminal, all software and documentation. Software includes BASIC interpreter, BASIC compiler, assembler, editor, and more: $2800. Mel Woolf, 10808 Midsummer Dr., Reston, VA 22091, (703) 860-1315.

WANTED: To correspond with TRS-80 color computer users who wish to exchange software and information. Joel E. Yingst, 463 Maple St., Annville, PA 17003.

FOR SALE: Tektronix 4051, full memory, documentation, excellent condition: $3700. David F. Rogers, 817 Holly Dr. E, Rt. 10, Annapolis, MD 21401, (301) 757-5724.

FOR SALE: IBM 5100 portable computer with two cartridge tape drives, IBM 5103 (132-column) printer, over 25 tape cartridges (some new), all manuals, cables, G/L, A/R, P/R, Inventory and mail-list software (plus several other business programs). Originally $15,000, will sell for $5000 or best offer. Will not sell items separately. Will pay shipping. M. Reardon, 17 Earl Lane, Rothsville, PA 17543, (717) 627-5353 (no collect calls).

FOR SALE: Digital Group equipment; single-density floppy-disk controller board: $125. Parallel-port board (4 in, 4 out): $45. Four Phi-Decks with cabinet, controller board, Phimon, and EPROM: $265. All in good working condition, but I haved switched to double density and don't need it. Harold E. Frye, 1551-5th Ave. SW, Rochester, MN 55901.

FOR SALE: Two S-100 8K static-memory boards. 100% functional: $75 each or both for $125. For Xerox copies of schematics and description, send 50¢ and SASE. Michael Scott, 2204-3 Arbor Circle, Downers Grove, IL 60515.

FOR SALE: 2708 EPROMs. I have about 275 EPROMs that were removed when equipment was upgraded to 2716. I will sell them at rock-bottom prices. All were working when removed. Perfect for the hobbyist. Make offer for all or part. Rick Matthews, POB 80685, Baton Rouge, LA 70898, (504) 291-0832 evenings and weekends.

FOR SALE: 22-slot TEI S-100 chassis, factory-assembled industrial grade, never used. Will sell or trade for serial printer. Sanders 722 display and keyboard with prints: $50 or best offer. Philip L. Edelsberg, 4148 West Breese Rd., Lima, OH 45806, (419) 999-5363 evenings or 226-4324 days.

WANTED: Memorex 550 flexible disk drive. James Mantooth, 2351 Interlackin Circle, Cleveland, TN 37311, (615) 479-8015.

FOR SALE: 64K MFP-II home computer totally compatible to the Apple and Franklin Ace. It contains color, graphics, low and high resolution, radio-frequency modulator, etc.: $399. Abbey A. Perez, 7943 Kenton, Skokie, IL 60076, (312) 677-9118.

FOR SALE: Medical computer books. Computers in Medicine-An Introduction: $18. Computers in Laboratory Medicine (clinical labs and nuclear medicine): $34. Microcomputer Programs in Medicine (BASIC program listings for scheduling, billing and graph plotting): $80. T. Armstrong, Box 874, Center Moriches, NY 11974.

FOR SALE: Mint 48K Apple II motherboard with Applesoft: $395. 5-Amp power supply: $85. Money order preferred. V.L. Davenport, 113 Coventry Court, Naperville, IL 60565, (312) 420-1415 evenings and weekends.

FOR EXCHANGE: Commodore 64 programs. Send your list with brief explanation and so will I. Arcade, board and/or adventure games, educational and/or tutorial programs, especially. A partial list dof what I have: Rubik's Cube solution, Yahtzee, Backgammon, Monopoly, Blackjack, Othello, Breakout, and Firefighter. 5¼-inch floppy disk or tape cassette. Lynn D. Lerner, 7908 Venetian St., Miramar, FL 33023.

WANTED: SD Systems users—I have several 8-inch DS/SD floppy disks, the contents of which I would like read and printed or transferred to a more portable format (such as IBM 3741). The data was written on an SD Systems with Versafloppy controller. Willing to pay for the services rendered. Bill Sheffler, 253 J Ave., Coronado, CA 92118, (619) 435-8333.

BOMB
BYTE's Ongoing Monitor Box

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May BOMB Winners

Jerry Pournelle's eclectic User's Column, "Ulterior Motives, Lobo, Buying Your First Computer, JRT Update," placed first in the May BOMB contest. Jerry will take home the $100 prize. The second-place award for $50 goes to Steve Ciarcia for his article, "Build an RS-232C Code-Activated Switch." Rich Malloy, a BYTE technical editor, earned third place for "Little Big Computer," a review of the TRS-80 Model 100 Portable Computer.

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